AGRICULTURAL ENGINEERING

JULY • 1952

Effect of Length and Width on Strength of Glued Joints *Henry Giese and C. E. Hamlin*

Some Effects of Land Drainage on Agricultural Production *Lewis A. Jones*

A Review of Progress Toward Greater Safety in Agriculture *C. L. Hamilton*

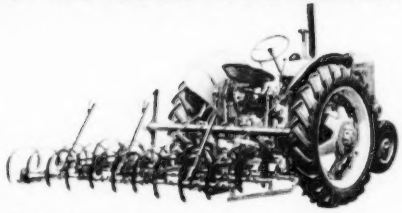
New Data on Harvesting and Conditioning of Grain for Storage *L. W. Hurlbut et al*

Results from a Forced-Circulation Tobacco Curing System *E. M. Matthews and V. H. Baker*

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

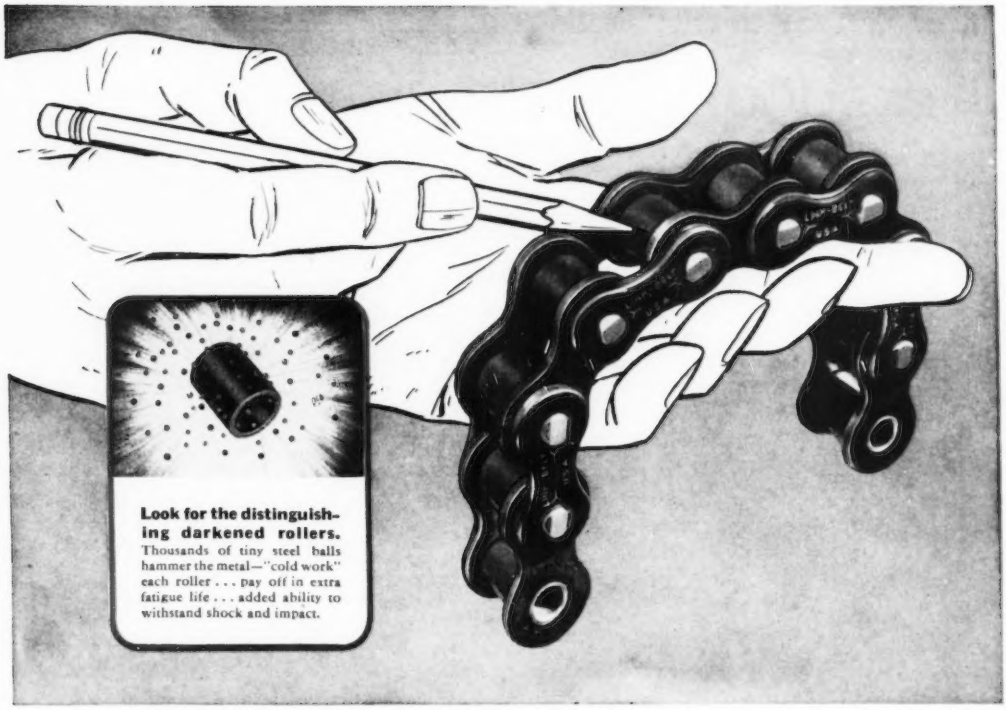
EAGLE HITCH FARMING IS CONSERVATION FARMING...

It conserves farmers' time and energy, promoting better soil and water management. With Case Eagle Hitch Tractors and matching mounted implements it takes but a minute to hitch up right from the tractor seat; takes but a moment to adjust working depth. Break-Away Contour Plow (above) turns uniform, even-width furrows on contour curves—makes contour plowing more practical. It uncouples, undamaged, when it hits stump or stone. Lifted by hydraulic power, it skips over waterways without scratching sod. Other Case Eagle Hitch Implements are equally advanced in concept and function.



Eagle Hitch Implements include this lift-type springtooth harrow. At a touch of the hydraulic control it shakes out trash or lifts clear to travel without contact. Ask for Eagle Hitch Implement Catalog—also for "Visual Aids to Modern Farming." It catalogs 60 films, charts, and other educational items—all available to instructors, classes or groups by request through any Case dealer or branch house. J. I. Case Co., Racine, Wis.

CASE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Thousands of tiny steel balls hammer the metal—"cold work" each roller . . . pay off in extra fatigue life . . . added ability to withstand shock and impact.

It's the SHOT-PEENED rollers that give your roller chain extra life!

. . . one of the extra-wear features you get with every LINK-BELT Roller Chain

POWER-TRANSMISSION engineers and metallurgists agree—shot-peened rollers mean longer roller chain life. That's just one of the engineering extras you get with Link-Belt Precision Steel Roller Chain. Another is Link-Belt's exclusive lock-type bushing.

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Link-Belt builds a complete line of roller chain—single or multiple widths in $\frac{3}{8}$" through 3" pitch; and double pitch, 1" through 3". Submit your chain problems to the Link-Belt office near you.

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AGRICULTURAL ENGINEERING

Established 1920

CONTENTS FOR JULY, 1952

Vol. 33, No. 7

EDITORIALS 409

EFFECT OF LENGTH AND WIDTH ON STRENGTH OF GLUED JOINTS 411
By Henry Grese and Charles E. Hamlin

EFFECTS OF DRAINAGE ON AGRICULTURAL PRODUCTION 415
By Lewis A. Jones

EVAPOTRANSPIRATION ESTIMATES AS CRITERIA FOR DETERMINING TIME OF IRRIGATION 417
By C. H. M. van Bavel and T. V. Wilson

PROGRESS TOWARD GREATER SAFETY IN AGRICULTURE 419
By C. L. Hamilton

HARVESTING AND CONDITIONING GRAIN FOR STORAGE 421
By L. W. Hurlbut, G. M. Petersen, F. D. Yung, and E. A. Olson

THE CORNELL SOIL PENETROMETER 425
By C. W. Terry and H. M. Wilson

WOOD TRUSSED RAFTERS 426
By Paul W. Stonebarner and E. George Stern

THE RILEY SPRAYOGRAPH 428
By G. L. Shanks and J. J. Paterson

A FORCED-VENTILATION TOBACCO CURING SYSTEM 429
By E. Martin Matthews and Vernon H. Baker

DRAINAGE PRACTICES AND PROBLEMS IN PUERTO RICO 430
By M. A. Lugo Lopez and M. B. Martinez

THE 1952 ASAE GOLD MEDALISTS 431

NEWS SECTION 434

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INDEX TO ADVERTISERS

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Aetna Ball & Roller Bearing Co. 405
Bendix Aviation Corp. 406
Bethlehem Steel Co. 391
Blood Brothers Machine Co. 408
J. I. Case Co. 2nd cover
Chain Belt Co. 398
Chrysler Corp. 400
Clark Equipment Co. 433
Cleveland Graphite Bronze Co. 451
Dayton Rubber Co. 394
Dearborn Motors Corp. 449
Durkee-Atwood Co. 439
Eaton Mfg. Co. 392, 403
Fafnir Bearing Co. 445
International Harvester Co. 407
Libbey-Owens-Ford Glass Co. 393
Link-Belt Co. 389, 401
Marlow Pumps 442
Masonite Corp. 443
Mechanics Universal Joint Div., Borg-Warner Corp. 397
Milsco Mfg. Co. 444
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U. S. Steel Co. 441
Aeroquip Tube Corp. 410
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Bethlehem Soft-Center Steel is economical, for two reasons. First, it will stand up under long, rough service. Second, its excellent machining properties mean that any cold fabrication required can be done easily in your shop. What's more, Bethlehem Cut-and-Formed Shapes made from this steel reach you accurately sheared to pattern. Since there's no waste, you pay freight charges for only the steel you use.

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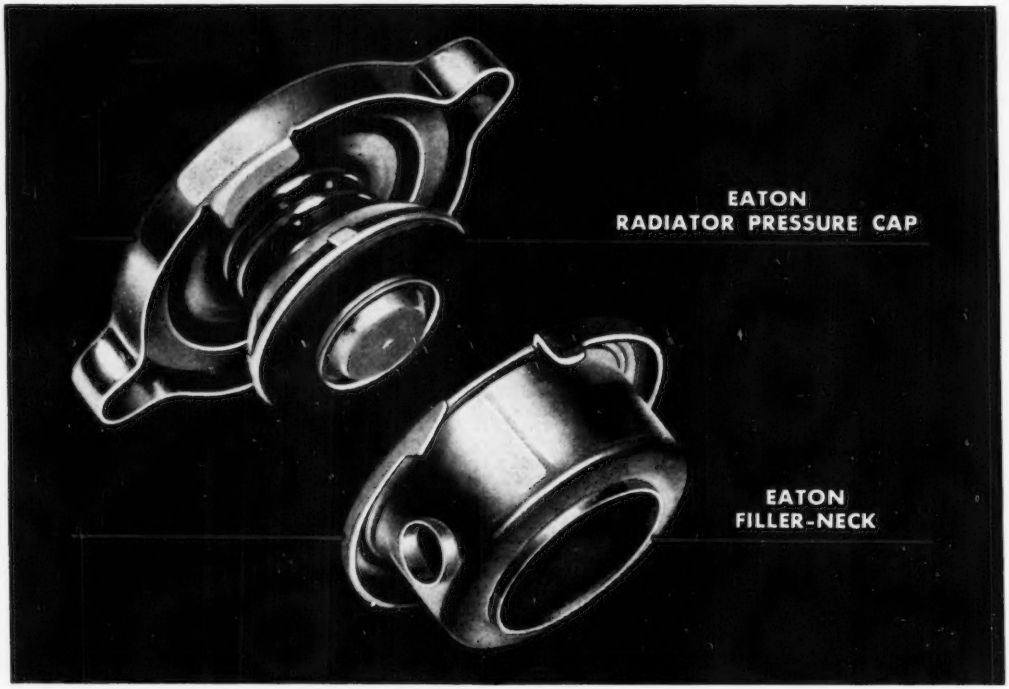

This Pair Makes Engines Run Better

By sealing the cooling system, the Eaton pressure relief cap causes a small amount of vapor pressure to build up, raising the boiling point of the coolant. This permits engines to operate in a more efficient and more economical temperature range without boiling away water or anti-freeze; it provides for smoother engine performance, better lubrication, quicker warm-up, improved heater operation.

The Eaton pressure relief cap is a safeguard against loss of coolant through either surge or evaporation. This is extremely important where water is scarce or where the constant addition of water tends to build up alkaline deposits in the system. With a sealed cooling system vehicles can be designed with smaller radiators at considerable saving in cost.

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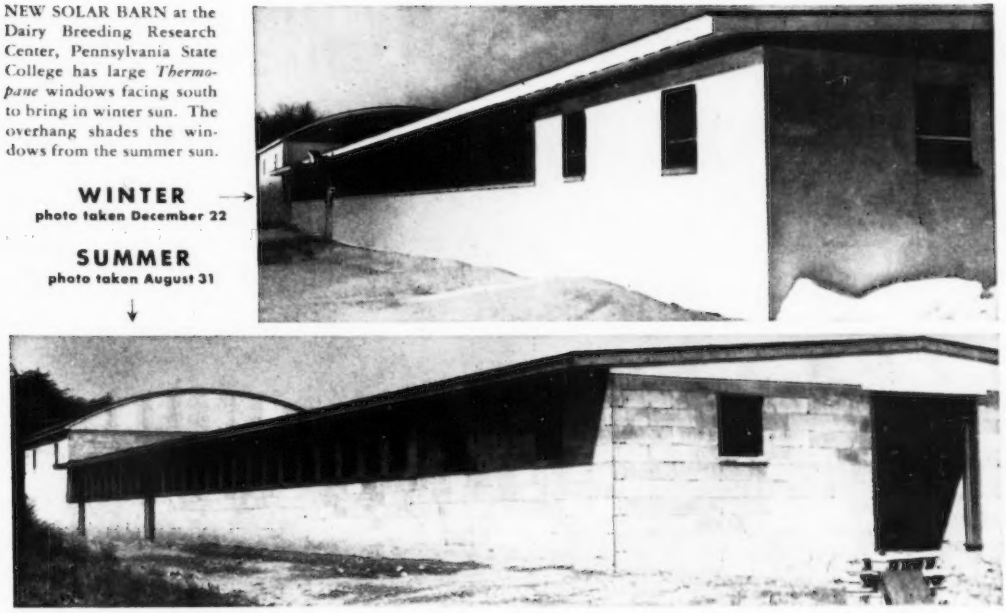
ORIGINATORS OF THE BAYONET-TYPE CAP AND FILLER-NECK FOR PRESSURIZED COOLING SYSTEMS

NEW SOLAR BARN at the Dairy Breeding Research Center, Pennsylvania State College has large *Thermopane* windows facing south to bring in winter sun. The overhang shades the windows from the summer sun.

WINTER →
photo taken December 22

SUMMER
photo taken August 31
↓



HOW TO TURN SUNLIGHT ON AND OFF

With solar farm building architecture you can bring in the winter sun to keep interiors warmer and drier—for better animal health and production. And you can shade out the summer sun.

This barn shows how. It employs three basic principles of good solar barn design:

1. Large windows face south to admit warm sunshine in winter.

2. The windows are glazed with *Thermopane** insulating glass. *Thermopane* helps keep more warmth inside, especially on cold nights. With warmer air, the ventilating system is better able to carry off moisture and maintain a drier interior.

3. Notice the roof overhang lets the low winter sun enter through the big windows, but shades them from the high summer sun. In summer, *Thermopane* helps insulate against extreme outdoor heat.

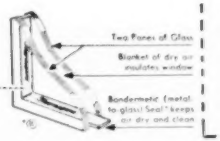
L·O·F's new Farm *Thermopane*, is designed to help you glaze service buildings at lower cost. It is made with the same time-proved, metal-to-glass *Bondermetic Seal** that has proved itself in more than 2,500,000 *Thermopane* units.

It has a ½" blanket of air between the two panes. But it is made with heavy sheet glass ($\frac{3}{16}$" thick), not plate glass. Hence, it costs less. It comes in three sizes—36" x 44", 36" x 60" and 40" x 68". Smaller units (for ventilating sash) are available in low-cost, double-strength window glass and have ¼" air space.

With these two types of *Thermopane*, you can provide excellent window insulation for all types of farm service buildings—with or without forced ventilation. *Thermopane* is sold by glass and building supply distributors and dealers. Mail the coupon for full information.

L·O·F GLASS *Thermopane*

LOOK FOR THE NAME ON THE SEAL BETWEEN THE PANES



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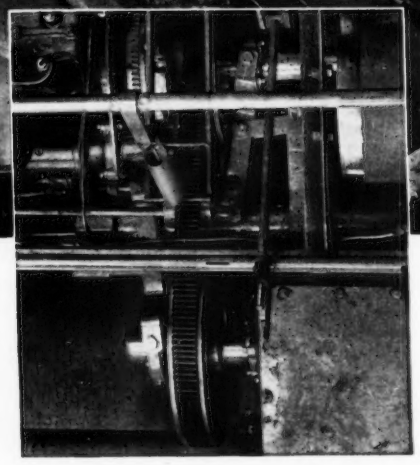


Photos courtesy Massey-Harris

This ingenious Double Cog-Belt installation on the Massey-Harris self-propelled corn picker serves as both clutch and transmission, giving 24 positively controlled speeds with only 1 change of gears in the 2-speed gearbox.

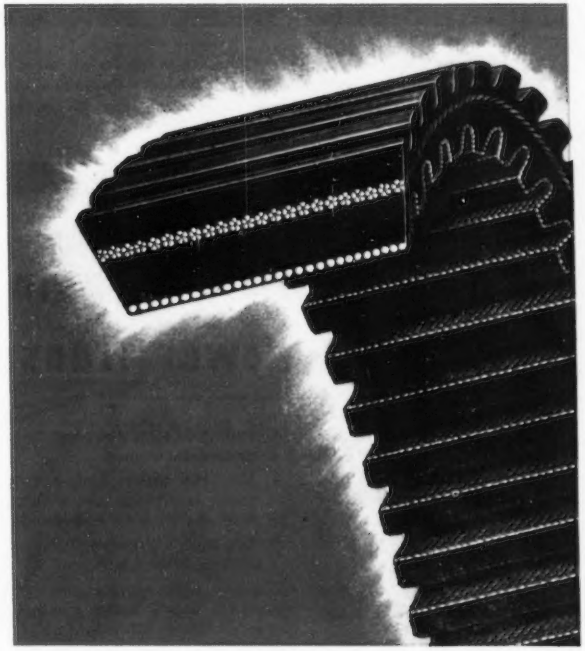
Double Cog-Belt

on your variable speed traction or propulsion drives!

Investigate the new Dayton Double Cog-Belt —and you'll see why we say it's the closest approach yet to the theoretically perfect belt for variable speed drives! Its neutral axis is as thin as possible—to offer very little resistance to bending. Yet the *cogs at top and bottom* give great transverse rigidity. It is lighter in weight, reducing centrifugal forces . . . has fewer internal stresses . . . greater radiant surface to dissipate heat.

What does this mean *in the field,* when you put Double Cog-Belts on farm implement variable speed drives? It means more accurate speed control, because of the rigid, constant belt cross section. And it means longer belt life . . . less vibration . . . cooler running belts . . . less power loss in the drive . . . greater load capacity . . . better pulley-to-belt mating.

Investigate this new, *patented* Double Cog-Belt for *your* variable speed drives. See for yourself how much better it is! Dayton Double Cog-Belts are available from leading farm equipment manufacturers, or from The Dayton Rubber Company, Agricultural Original Equipment Division, 1009 W. Washington Blvd., Chicago, Illinois.



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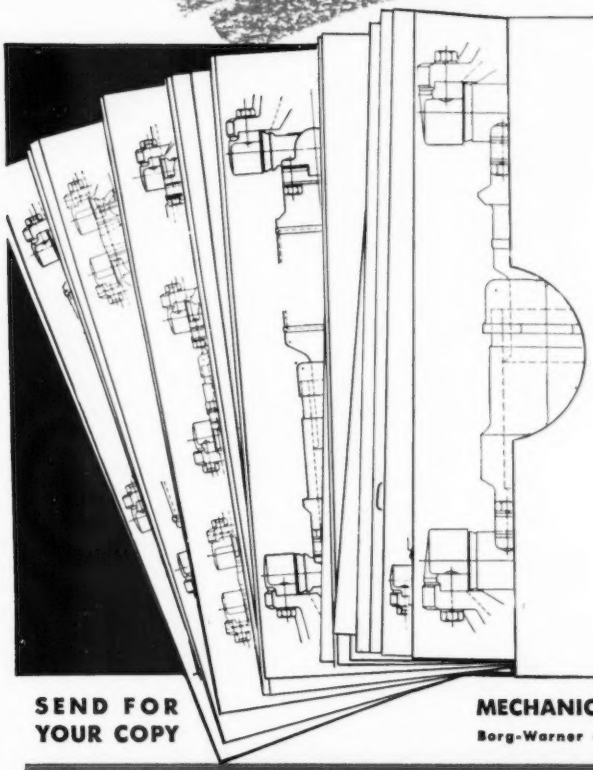

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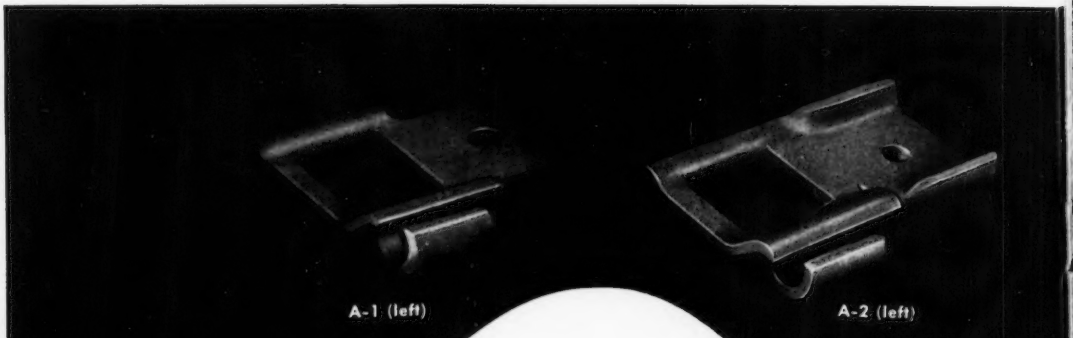

A-1 (left)

A-2 (left)

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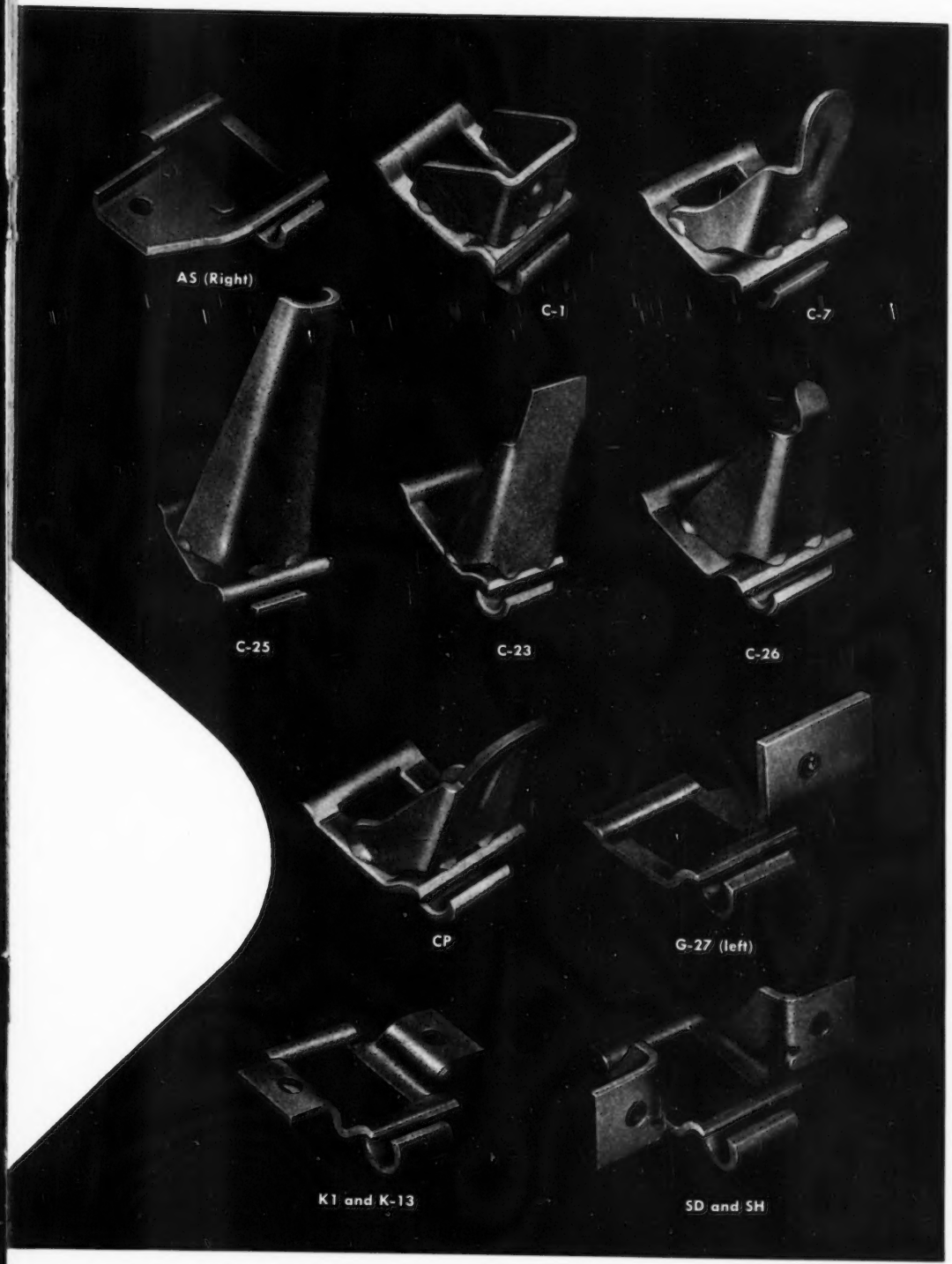
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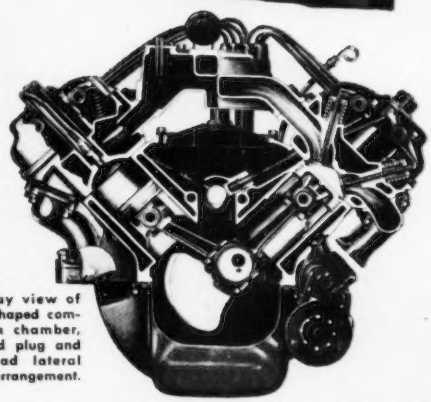
More Efficient Cooling is due to less heat rejection in the combustion chamber. More heat is turned to power. More coolant flows around valves and bore. Water jacket completely surrounds cylinder. With *less coolant* this new engine *has better cooling* —a more compact, efficient, over-all cooling system!

These are only a few of the important developments made in Chrysler Industrial V-8's. There are many more. *These* engines will give you a whole new conception of Industrial power. Ask a Chrysler Industrial Engine Dealer to explain their advantages on your jobs, or write us direct for full information. **Marine and Industrial Engine Division, Chrysler Corporation, 12200 E. Jefferson Ave., Detroit 31, Michigan.** *Model IND-40



Cutaway view of dome-shaped combustion chamber, centered plug and overhead lateral valve arrangement.

CHRYSLER
Industrial V-8 Engines

Why "total engineering" of screw conveyors means better performance for your machines

LINK-BELT conveyor screws and components are engineered to give you the right screw conveyor for your particular needs

THERE are many important factors in conveyor screw construction that must be correlated to give you top screw conveyor efficiency. That's why Link-Belt's "total engineering" is so vital to you . . . why Link-Belt conveyor screws are first choice of so many leading designers.

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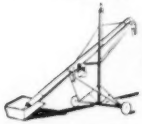
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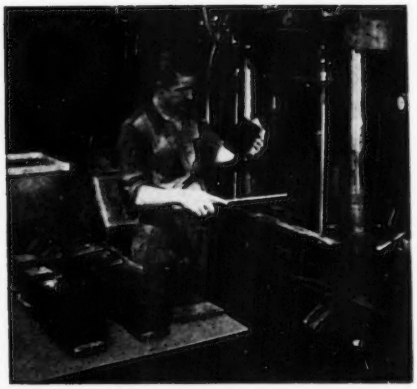
New source of plastics for the automotive industry at United States Rubber Company's Chicago Die Mold plant



One of the 40 Plunger Transfer and Compression presses in U.S. Rubber's new Chicago Die Mold Plant.

This is the newest unit in the nationwide chain of plants and laboratories which comprises United States Rubber Company.

This modern new plant houses the productive facilities and scientific personnel for wider excursions into the field of plastics, in the form of moldings, extrusions and fabrications.

For the automotive industry, this plant will produce plastics molded by injection and compression (transfer or plunger). It has its own mold manufacturing facilities. The equipment is of the most advanced type, and the engineers have at their command the great research stockpiles of the United States Rubber Company. This Chicago Die Mold Plant will supplement the "U.S." plant and laboratory at Fort Wayne serving the automotive industry.

Other equipment in the plant includes 20 Injection Machines, with controlled mold temperatures.

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UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

the chilled-iron face gives Eaton Tappets superior load-carrying capacity and longer life

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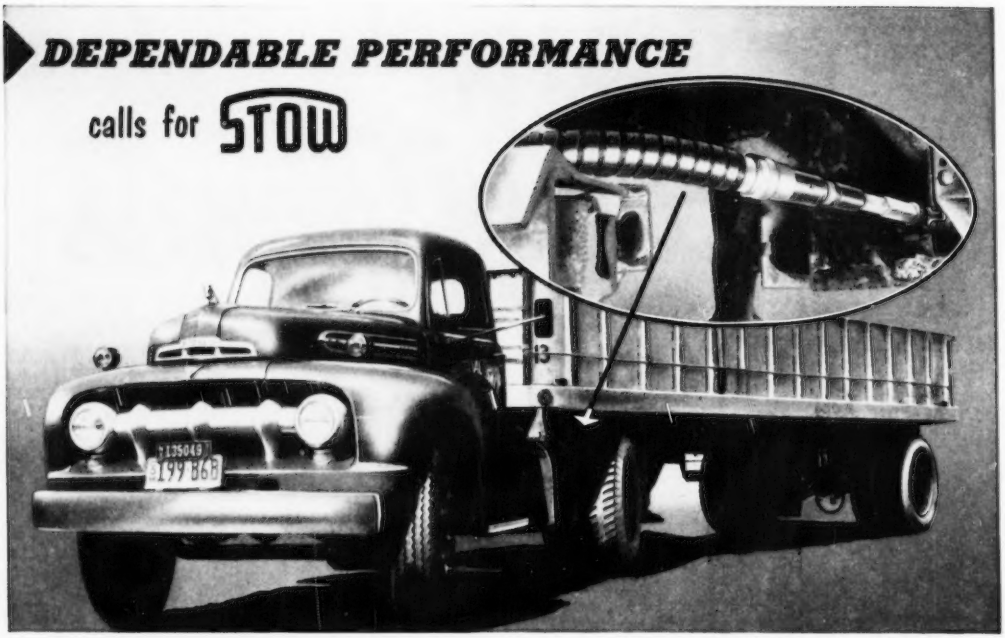

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"We thought you might like to know how pleased we are with the performance of your flexible shafting on our rock salt delivery units. As you know, we had a real maintenance problem with the method we previously used.

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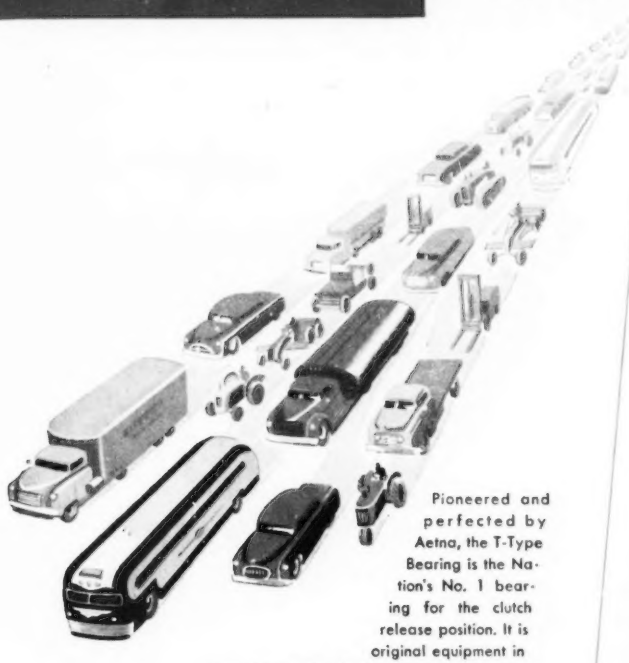

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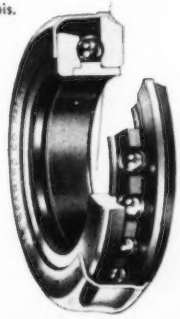
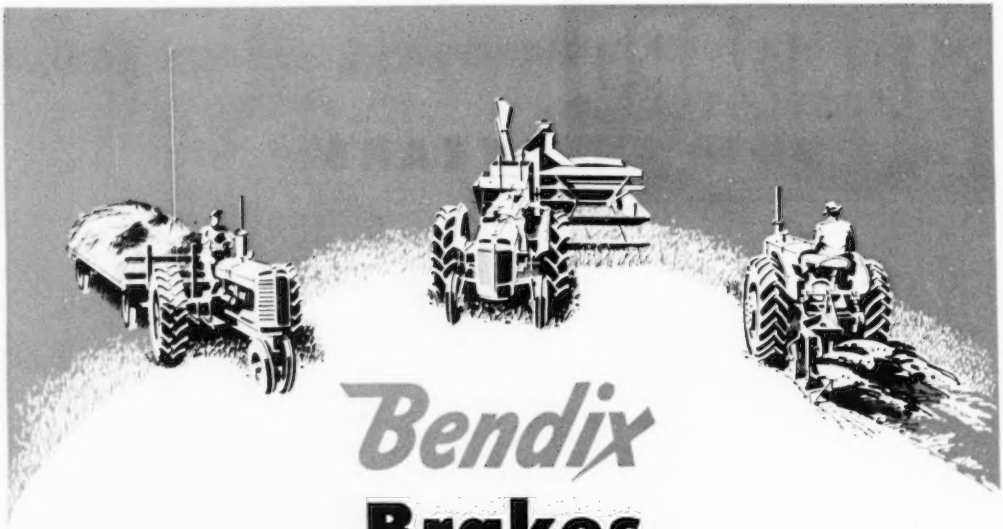
Pioneered and perfected by Aetna, the T-Type Bearing is the Nation's No. 1 bearing for the clutch release position. It is original equipment in more than half of the "on-and-off-the-highway" mobile vehicles built today. Add this bearing's 18-year leadership to its matchless features — to Aetna's traditional practice of cooperative research and engineering — to Aetna's ultra-strict quality control methods and manufacturing skill and you have every significant reason why Aetna is the recognized source of the world's finest clutch release bearings. Aetna Ball and Roller Bearing Company, 4600 Schubert Avenue, Chicago 39, Illinois.



Aetna

T-TYPE CLUTCH RELEASE BEARINGS



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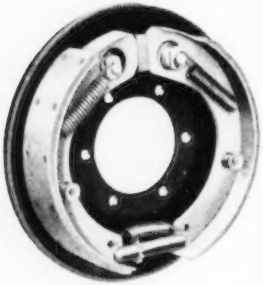

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BE CAREFUL
1 KEEP ALL SHIELDS IN PLACE
2 STOP MACHINE TO ADJUST AND OIL
3 WHEN MECHANISM BECOMES CLOGGED DISCONNECT POWER BEFORE CLEANING
4 KEEP HANDS, FEET AND CLOTHING AWAY FROM POWER DRIVEN PARTS.
5 KEEP OFF IMPLEMENT UNLESS SEAT OR PLATFORM IS PROVIDED
KEEP OTHERS OFF

IT PAYS to Promote Farm Safety

Carelessness kills customers . . . creates an impression that equipment involved in an accident may be dangerous. These are two good reasons why you should talk farm safety. Make sure customers know how to operate new IH equipment. Point out safety devices. Remind farmers that careless operation makes any machine dangerous, that thoughtlessness is partly to blame in nearly *all* accidents.

Good luck is usually good housekeeping. Every year thousands of farmers are injured by falls. Slipping on a corn cob or stepping into a hog wallow breaks arms and legs just as surely as tumbling from a ladder. Here's a farmer using his McCormick Farmall tractor equipped with a leveling and grading blade to tidy up a feed lot. Reducing hazards reduces farm accidents.

Proper maintenance is better than a rabbit's foot. Frequent stops for adjustment or repair often anger operators—tempt them to take needless chances. Your pre-season IH 5-Star Service can head off most of these accident-breeding irritations. Here's an IH serviceman installing in a McCormick corn picker a new device for adjusting snapping rolls from the tractor seat.

Safe work habits beat a four-leaf clover. Safety is an important factor in the design of McCormick farm equipment. No machine, however, is safer than its operator. That's why you should constantly remind farmers to keep safety shields in place; to stop machines for lubrication; and to observe all the other safety precautions listed on the "BE CAREFUL" tag McCormick machines carry.

Observe Farm Safety Week—July 20-26. Help your customers to think safety every week on the farm.

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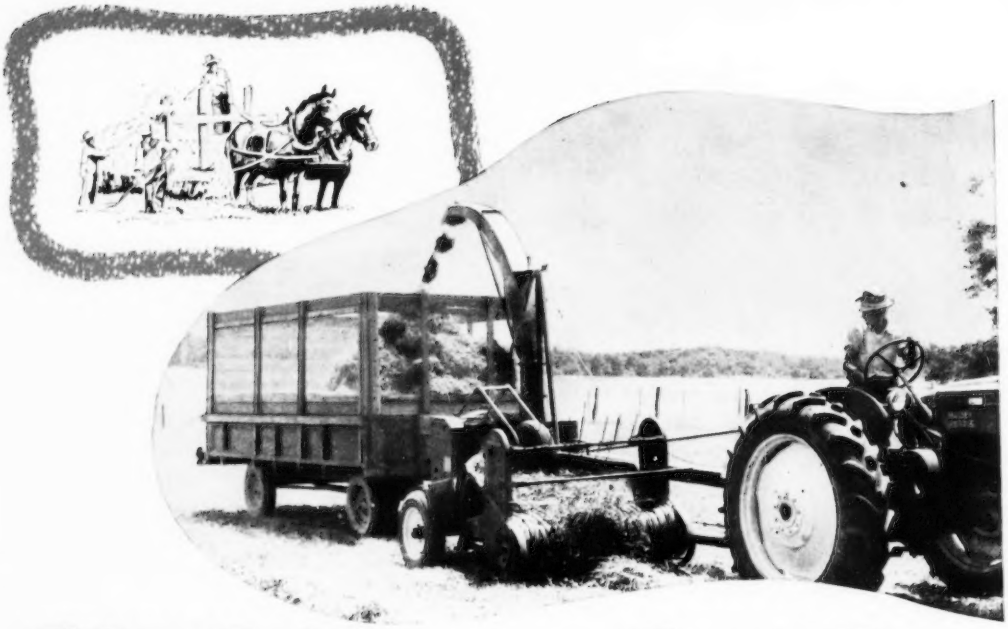


PROGRESS through POWER

—on implements doing new jobs
power is delivered through

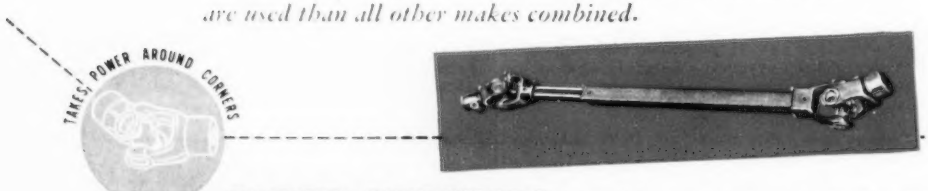
BLOOD BROTHERS Universal Joints

Many improvements in haymaking implements are refinements of old tools. But not the forage harvester, like the New Holland model shown here!

For thanks to the applied technology of the Agricultural Engineer, it does a *new job*... in part, a job that wasn't done at all with older methods. The result, of course, is vastly more nutritious food for stock—and better returns for the farmer.

The future will see other changes that make farming easier and more profitable. And as new implements are designed, Blood Brothers Universal Joints will help speed progress with dependable power transmission in vital spots.

For farm implements, more Blood Brothers Universal Joints are used than all other makes combined.



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EDITORIAL

Engineering Against Human Carelessness

FARMING is well and unfavorably known to be one of the world's most hazardous occupations. One of the circumstances contributing to farm hazards apparently is the wide variety of work done by many farmers. A part of their work is daily routine in which overfamiliarity may lead to accidents. Another part is occasional or new work in which lack of acquaintance with the hazards involved contributes to loss of life and limb.

In connection with these special jobs farmers often have occasion or temptation to temporize and resort to expedients in man power, equipment and methods, balancing unknown risks against the possibility of getting a job out of the way quickly and at minimum cost.

The farmer may have to work alone on a two or three-man job, or he may on occasion have a dangerous surplus of willing volunteer help not well-trained for the job or practiced in working as a team. He deals at varying intervals with high-tonnage wind, water, gravity and velocity forces; position, enclosure, obstruction, balance, footing and hand-hold hazards; dangerous pressures, chemicals, explosives, animals, machines, overhead loads, and lethal combinations of electrical amperage and voltage. Due to economic pressures, special interests or other circumstances the equipment with which he deals with these hazards may be poorly suited to the job, or inadequately maintained.

Much of this time he may be working with no technical help on the spot, only the sketchiest instruction on unfamiliar matters, and little or no previous contact, direct or indirect, with any farm safety specialist.

At the same time his mind may be occupied with meeting various biological or other operating requirements for effective production, or with marketing, management, or personal problems. As a matter of fact, many farm accidents commonly ascribed to carelessness might more accurately be described as due to preoccupation.

It is these circumstances, we submit, that are largely responsible for the high farm accident toll. We find little evidence that farmers as a class are more negligent or careless with their own safety and that of others, than are proprietors and operators of other forms of business using the same number of workers per production unit.

There are simply too many different things for a farmer to be careful about! He faces a number of hazards and competing demands upon his attention, simultaneously or in quick succession, which often exceeds the human capacity for concentration.

As a result, it is not only the lunatic fringe of unconscionably careless farmers who are getting hurt. Victims of serious farm accidents include far too large a number of normally careful, intelligent, and highly desirable citizens.

That makes it specially gratifying to note the emphasis on "engineering against human carelessness" in the article, entitled "Progress Toward Greater Safety in Agriculture", published elsewhere in this issue. Anything which engineering can do to reduce hazards for the most careless farmer will also reduce hazards for the normally careful farmer, and enable him to concentrate more effectively on remaining hazards and productive work.

Increasing farm safety involves agricultural engineering. It involves dealing with complicated combinations of physical realities concerning the capacities and limitations of the human mechanism, and the conditions encountered in farm environments and farm work.

Enough has been accomplished to strongly suggest further opportunities in the engineering approach to farm safety by design and development of additional foolproof features, more safeguards and warning devices, improved farm operation methods, analysis of accident records, and safety education material based on further engineering analysis of specific hazards.

Farm safety provides opportunity to work toward well-established engineering objectives — the elimination of waste; the conservation of human and natural resources. The conservation represented by accident prevention is obvious. Conservation by reducing the attention required to prevent accidents is less obvious but also important.

Industry's New Stake in Engineering Education

AT THE Industry-Research Conference held in East Lansing, May 12-14, three executives of the farm machinery industry were discussing the current shortage of engineers. Four opinions as to the reason for the shortage were expressed.

1 The responsibilities of world leadership thrust upon us during and since World War II were of a magnitude not fully comprehended by our political, educational, and industrial leaders. This situation has been demanding of scientific and technically trained personnel, including engineers, to an extent not anticipated by those in authority.

2 Too many engineers fully qualified for technical departments have been allowed to drift into sales, sales promotion, and general administrative assignments. An ever-increasing number are being drafted from technical duties to perform in executive capacities.

3 In the past a significant proportion of engineers have been developed from the ranks of labor. Starting as lads without experience, it was possible for many, through self-improvement and application, both on and off the job, to qualify for positions of responsibility in engineering departments. Under present restrictions incidental to some labor organization, this procedure is becoming less common.

4 In recent years engineering graduates have been more and more inclined to look with disdain on long periods of engineering apprenticeship. Hours over the drafting board have lost their appeal in favor of junior executive positions. Yet, according to seasoned engineering opinion, designs and their improvement are still born in the mind of the engineer and are developed, usually rather tediously, on the drafting board.

Although they didn't have the answer as to how to alleviate the shortage, these executives did agree that industry has an increasingly greater stake in engineering education. It was apparent that they were thinking of how their respective organizations could best cooperate with colleges and universities in developing the number and quality of engineers required for our economy.

Practical Recognition

ONE of the places in this mundane world in which agricultural engineers might gain practical recognition of value to them and their clients is the classified telephone directory.

We had been under the impression, apparently erroneous, that a subscriber to a business telephone might on his own request be listed as a pretzel bender, or for whatever type of specialized business, professional, or commercial service he might be prepared to render. Apparently it is not that easy if the classification requested is new to the publisher. One established agricultural engineer recently furnished us a copy of his second request to the publishers for listing as an agricultural engineer in the classified telephone directory for Chicago.

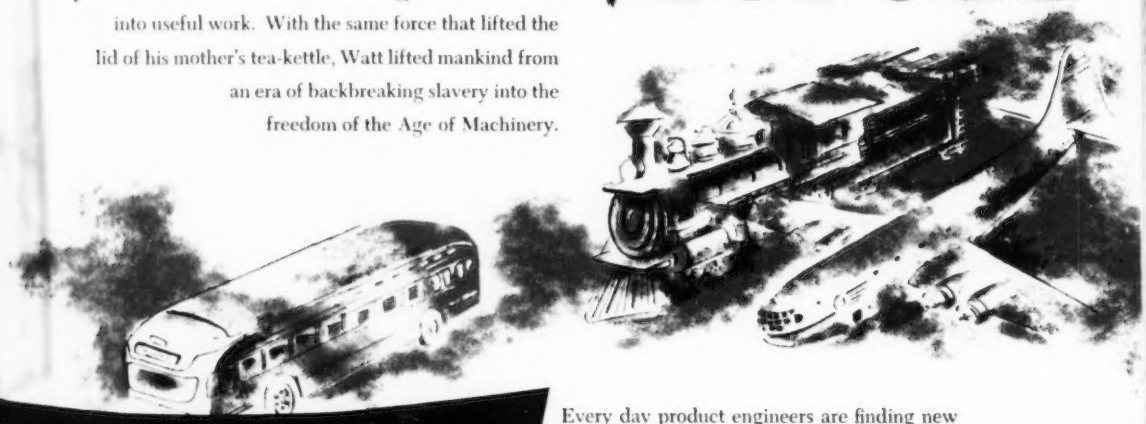
Branches of engineering with large numbers of representatives, such as mechanical, they list separately, but in the case of branches with small numbers of individuals represented, they prefer to simplify their classification problem by throwing them into the list of general consulting engineers.

This is a denial of the directory's classifying function, apparently based on a lack of information or appreciation of the degree of specialization represented within the general field of engineering. It operates to the disadvantage of agricultural engineers and their present and potential clients.

Have others elsewhere been listed as agricultural engineers in classified telephone directories, or denied such listing? If so their experience might help some of our members in Chicago.

Vision

Through centuries of toil, there had been within man's hands the giant Steam, merely awaiting the vision of James Watt to harness its wasted energy and transform it into useful work. With the same force that lifted the lid of his mother's tea-kettle, Watt lifted mankind from an era of backbreaking slavery into the freedom of the Age of Machinery.



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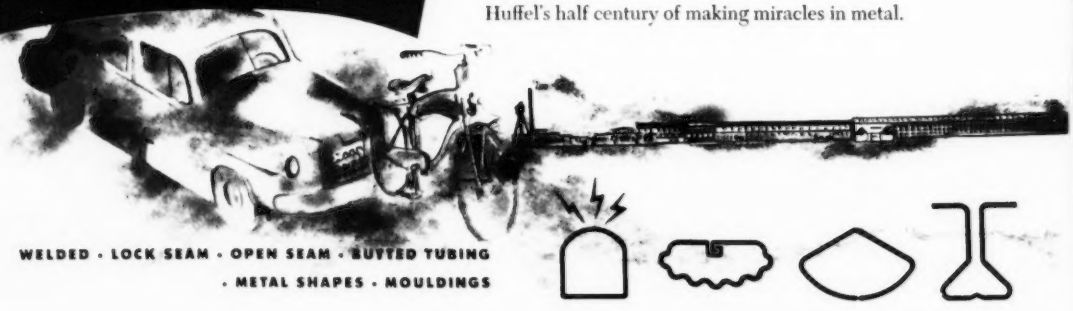

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AGRICULTURAL ENGINEERING

VOL. 33 JULY, 1952 NO. 7

Effect of Length and Width on Strength of Glued Joints

By Henry Giese and Charles E. Hamlin

FELLOW ASAE ASSOC. MEMBER ASAE

FROM earlier studies by Palmer (6, 8),* it became apparent that the ultimate strength of glued shear joints did not vary in direct proportion to changes in size. This series of tests was planned with the objective of determining the relationships involved and their influence upon values to be used in design. Three angles of approach were employed:

1 Ultimate strength tests on shear joints of varying size

2 Stress distribution in photoelastic models

3 Stress distribution as indicated by strain gages on glued wood joints.

SHEAR TESTS ON GLUED JOINTS

The tests consisted of loading to failure a total of 1280 joints, ranging in increments of 1 in. from 1 in in width and 1 in in length to 8 in in width and 8 in in length, as detailed in Fig. 1.

Twenty joints of each of the 64-size combinations were tested. Extremes in sizes appear in Fig. 2.

Method of Procedure. Since modern glues are stronger than wood, the strength of the wood becomes the dominant factor in the strength of glued timber joints. Therefore, the wood was selected for uniformity. In addition, specific gravity tests were made of specimens cut from each end and middle section of each piece. These tests were made on an ovendry basis by the immersion method.

At the time of construction of the joints, moisture determinations were made with a Tag-Heppenstall moisture meter on each piece of wood making up a joint assembly. The average moisture content so found was 9 per cent, with a maximum variation among individual pieces of 2 per cent. Random moisture readings after a 13-day curing period showed no appreciable change. The Casco grade A casein glue was mixed by weight measure, one pound of glue powder to two pounds of water, to insure quality and uniformity. The glue was applied to the wood with a stiff-bristled paint brush and the joints assembled immediately. All joints were made with parallel arrangement of the grain in the separate pieces. Pressure was applied to the glue line by one 4d common nail for

TABLE 1. ULTIMATE STRENGTH OF GLUED SHEAR JOINTS
(Pounds per square inch)

Group	Maximum	Minimum	Average	Group	Maximum	Minimum	Average
11	1015	463	690	51	1485	680	1022
12	1663	788	1059	52	1455	495	771
13	1392	708	1018	53	962	527	729
14	925	490	671	54	981	530	761
15	1085	400	742	55	1064	632	845
16	835	418	621	56	943	517	670
17	886	507	701	57	823	580	722
18	847	450	666	58	605	290	486
21	925	400	658	61	1271	433	758
22	1362	525	918	62	1442	542	874
23	1450	590	1024	63	1231	564	909
24	1238	456	724	64	1178	705	980
25	1088	525	778	65	1000	379	734
26	977	523	738	66	817	518	686
27	929	471	711	67	780	383	656
28	813	500	642	68	761	414	646
31	1208	425	729	71	1211	718	977
32	1221	546	854	72	1350	371	797
33	1075	494	749	73	1190	644	907
34	1042	698	891	74	848	429	690
35	1015	660	815	75	900	440	676
36	936	582	755	76	967	617	841
37	742	418	602	77	845	496	767
38	786	426	620	78	798	497	654
41	1228	620	745	81	806	444	637
42	1165	638	817	82	800	330	585
43	1277	696	1053	83	932	428	732
44	930	528	746	84	1319	541	864
45	1114	556	925	85	1061	594	823
46	809	430	686	86	950	540	730
47	854	639	748	87	790	641	721
48	719	527	652	88	677	430	550

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1949, as a contribution of the Farm Structures Division. Approved for publication as Journal Paper No. J-2003 of the Iowa Agricultural Experiment Station (Ames), Project No. 1167.

The authors: HENRY GIESE, professor, and CHARLES E. HAMLIN, formerly research fellow, Iowa Agricultural Experiment Station, Ames.

*Numbers in parentheses refer to the appended references.

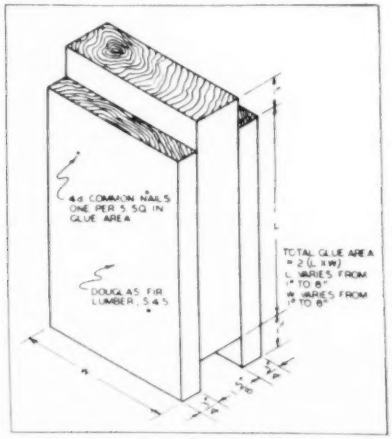


Fig. 1 Details of joints used for testing effect of joint sizes on unit strength

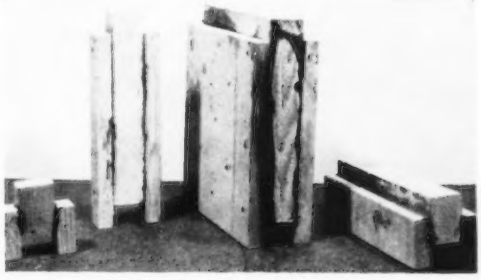


Fig. 2 Range in size of joints tested

Fig. 3 *(Extreme left)* Shear failures of 1-in joint members • Fig. 4 *(Left center)* Compression failures in 1-in members • Fig. 5 *(Right center)* Compression failures in 2-in members • Fig. 6 *(Extreme right)* Failures in center member by splitting

each 5 sq in of glue area. These nails were not withdrawn when the joints were tested.

Precautions were taken to spread the glue uniformly over the areas in contact and to keep ends of the joints square for testing purposes. Joints were loaded to failure in a Southwark-Emery testing machine. Load was applied at the rate of 20,000 lb per min. The tendency of the joints to spread due to eccentric loading was resisted by a vise.

Results of Tests. Maximum, minimum and average joint strengths are given in Table 1. In the group designation, the first digit indicates the joint width and the second digit the joint length (i.e., No. 35 represents a joint 3 in wide and 5 in long).

It will be noted that there was a wide range in the strength of individual specimens. Minimum strength may be of more significance to the designer than either the maximum or average. Of the nine joints (0.7 per cent of the total) which failed at a stress of less than 400 psi, four were 2 in long, two 5 in long, one 7 in long, and two 8 in long.

Typical joint failures are shown in Figs. 3, 4, 5, and 6. In many of the longer joints, compression failures occurred in either the one-inch or two-inch members rather than along the glue line (Figs. 4 and 5). Fig. 6 illustrates joint failure resulting from the splitting of the center member in spite of the resistance offered by the vise.

Fig. 7 shows the effect of width or length variations upon the strength of glued joints. The curve showing average strength per 1 in of length was produced by considering all joint groups 1 in long. Values were then plotted for widths from 1 in to 8 in. The strength of a glued joint varies directly in proportion to its width. This relationship does not hold, however, when length is considered as the variable, as may be observed by the curve showing average load per inch of width which was obtained by considering joint groups 1 in wide and of variable lengths. The unit strength of short joints is reduced by the eccentricity of loading which tends to split the center member. As the joint is lengthened, tensile stresses across the center member becomes less in proportion to the load applied. On the other hand, as will be discussed more fully in connection with the strain gage observations, shear stress is not distributed uniformly along the length of the glue line but is considerably less in the center than at the ends. This tends to lessen the unit strength of the glue joint as the length is increased. The compressive strength of the wood members also

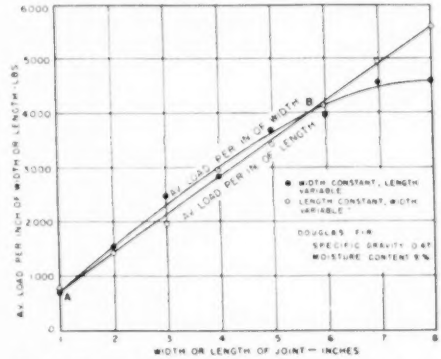
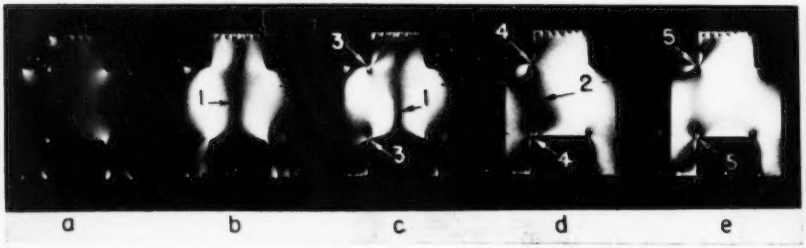


Fig. 7 Effect of width and length on the strength of glued joints

becomes a limiting factor in long joints. Considering the Douglas fir used in these tests, it appears that the maximum total joint strength was attained at a length of approximately 8 in.

ANALYSIS OF PHOTOELASTIC MODELS

Stress analysis by photoelasticity gives an immediate and tangible picture of the stress distribution in the model being investigated. The basic principle underlying photoelasticity is the property of certain transparent materials to be double refractive when under stress. If polarized light is passed through such a material, the light is broken up into two components which emerge as waves polarized in directions at right angles to one another. These waves also coincide with the planes of the principal stresses in the material. The velocity of light through the model is a function of the intensity of the principal stresses. When double refraction occurs, one of the waves emerging from the model passes through the material slower than the other. Thus as the two waves emerge from a loaded model, they are polarized at right angles to each other and with a certain relative retardation between them. After these two waves are passed through a polarizing analyzer disk they are polarized in the same plane. Because of the retarda-



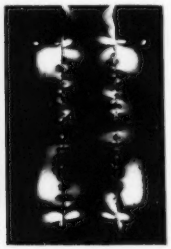


Fig. 8 *(Left)* Isoclinics and fringe lines in photoelastic model • Fig. 9 *(Right)* Photoelastic picture of glued model, 90 deg, no load

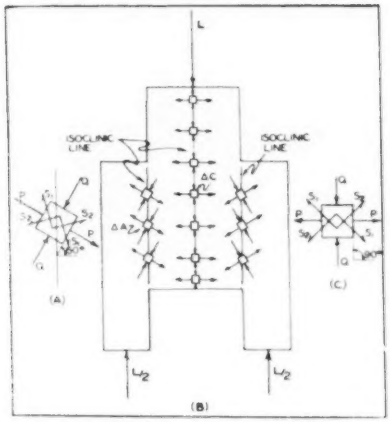


Fig. 10 Diagram showing direction of principal stresses and shears along isoclinic lines of photoelastic model

tion between the waves, interference bands are produced that may be interpreted as stresses. The stress conditions indicated by tests on photoelastic models are generally identical to the conditions existing in a full-sized unit under a similar load.

Method of Procedure. The models tested were made from a ¼-in sheet of a photoelastic material known as Columbia Resin, CR-39.

Three models were made in one piece thus representing the conditions of a perfect glue joint. For the fourth model, which was made to observe an actual glue line under polarized light, strips were cut to scale and glued together with "Lucite" dissolved in ethyl acetate.

The models were tested by placing them in the loading frame of the polariscope. A metal bearing plate, ¼x½x¾ in, was placed on top of the models to insure uniform load distribution. Load was applied to the models by means of weights placed on the small platform attached to the end of the loading beam. For study purposes pictures were taken of the photoelastic patterns set up in each of the models by different loadings and angular positions of the polarizing and analyzing disks. Particular attention was paid to obtaining data on the stress conditions along the imaginary glue line.

Analysis of Photoelastic Models. Before proceeding with the analysis of the results, it is necessary to define several terms used in photoelasticity.

An isoclinic line is the locus of points at which the principal stresses in a model all have the same inclination ϕ to a fixed direction of reference, the angle ϕ being the angle which the axes of the polarizer and analyzer make with the fixed direction.

The fringe line is the locus of points where the difference between the principal stresses is the same. In photoelastic models the fringe pattern shows up critical points and sections.

Fig. 8 shows the isoclinic lines and fringe patterns for one of the models. In a, b and c are shown the 90-deg isoclinic lines for a load of 4 oz, 3 lb 4 oz, and 6 lb 4 oz, respectively. In addition c shows the beginning of the fringe pattern at the top and bottom of the imaginary glue line. In d and e the 30-deg and 45-deg isoclinics are shown for a load of 6 lb 4 oz. The isoclinics we are interested in are indicated in the figures by the arrows marked 1 and 2.

For clarity the isoclinics marked 1 and 2 are shown diagrammatically in Fig. 10 with small elements placed along the lines to indicate the directions of the principal stresses. The isoclinic down the center of the model is for 90 deg. Therefore, the compressive forces act along this line and the tensile forces at right angles to it. Taking the small element ΔC out and enlarging it in C of Fig. 10, we have the compressive forces indicated by vectors marked Q and tensile forces by vectors marked P. The maximum shears in the element occur at 45 deg to the principal stresses and are indicated by the vectors S_1 and S_2. The isoclinic lines do not show the magnitude of stress but only their direction; however, from mechanics we know that at free boundaries the principal stresses are parallel and normal to the boundary, and the latter is equal to zero. From the 90-deg isoclinic down the center of the model, therefore, it is possible to verify the assumption that tensile forces caused splitting of the 2-in member in the actual joints. At the bottom of the isoclinic is a free boundary and the compressive stress is normal to this boundary and equal to zero; on the other hand, the tensile stress is parallel to the boundary and of maximum magnitude. Just the opposite occurs at the point of load application; here the compressive stress is a maximum and the tensile stress is a minimum.

Referring now to the isoclinic along the imaginary glue line. This is a 30-deg line, consequently the principal stresses act at 30 deg and 60 deg to the glue line and the maximum shears at 15 deg and 75 deg to the glue line. The direction of these stresses may be seen clearly from the small element ΔA which is enlarged in Fig. 10a. From this isoclinic then it is evident that the shear developed in the glue line is somewhat less than the maximum shears occurring in this portion of the model. In Fig. 8 d the 30-deg isoclinic appears on only one side of the model. If the polarizing and analyzer disk were rotated 60 deg, the isoclinic would appear on the other side of the model.

From the fringe lines it is possible to determine the critical sections in the model. The fringe lines are shown in Fig. 8 c, d, and e by the numbered arrows 3, 4, and 5. Notice that these fringe lines start at the upper and lower ends of the glue line, indicating that stresses are maximum at these points. Fringe lines are distinguishable from isoclinics in that they appear in all positions of the polarizer and analyzer disks. Note that the fringe lines in d are partly obscured by the isoclinic line blending in with them.

The fact that the extreme ends of the glue line are critical stress points proves there is uneven stress distribution along the glue line thus accounting for variations of unit strength with changes in size of glue joints.

In Fig. 9 the photoelastic picture of the glued model is shown. There is no load on the model. This latter picture helps to explain some of the variations in strength occurring among glued joints of the same size. Obviously there is no such thing as a perfect glue joint since evidence is produced here that glue tends to bond intermittently along the glue line. It is to be expected then that strength differences will exist between supposedly identical glued joints not only because of moisture and specific gravity differences of the wood, but also because of unevenness of glue bonding.

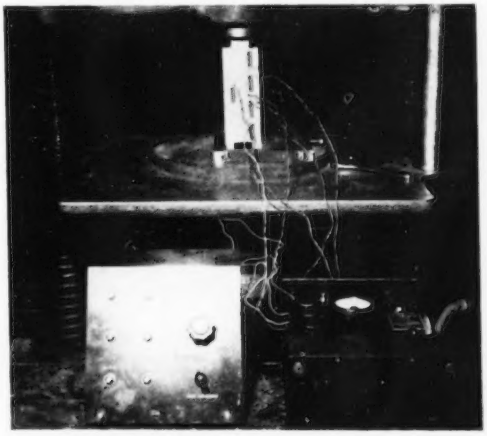


Fig. 11 Strain-recording equipment set up for testing

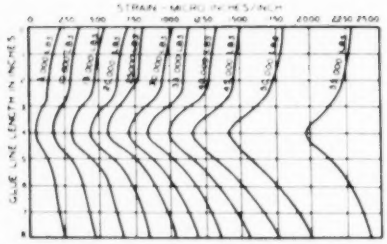


Fig. 12. Curves showing distribution of strains along glue line length for various loadings applied to a joint 4 in wide and 8 in long.

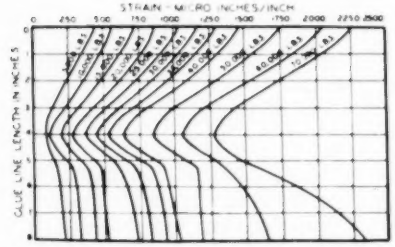


Fig. 13. Curves showing distribution of strains along glue line length for various loadings applied to a joint 8 in wide and 8 in long.

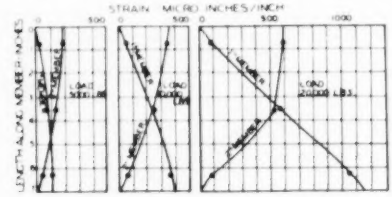


Fig. 14. Curves showing distribution of compressive strains in 1-in and 2-in members of a joint 4 in wide and 7 in long.

TESTS USING STRAIN GAGES ON GLUED WOOD JOINTS

SR-4 type A-1 strain gages were used in these tests. The recording equipment consisted of a SR-4 Type K portable strain indicator connected to the active gages through a 6-channel SR-4 bridge balance unit.

Method of Procedure. Before placement of the strain gages the wood surfaces were sanded and then treated with Baldwin's precoat cement. After the precoat cement had been allowed to dry for 15 min a liberal coat of SR-4 cement was applied to the surfaces where strain gages were to be placed. The gages were then pressed against the surfaces until the excess cement was squeezed out. Small one-pound weights were placed on the gages for a period of 24 hr while the cement dried. Solid, No. 18 copper wires were soldered to the leads of the strain gages. The leakage resistance between the lead wires and the ground was measured by a megger and in all cases was greater than 50 megohms, which was in accordance with specifications stated by the Baldwin Locomotive Works for SR-4 strain gages.

Placement of gages was made on and along the length of the glue line in the manner shown in Fig. 11. The gages were located so that strain readings could be taken at the following points measured down from the top of the glue line: 0.75, 2.75, 4, 5.25 and 7.25 in. On two of the joints tested gages were placed on the longitudinal center lines of the 1-in and 2-in members in order to find out the magnitude and distribution of compressive strains in these members. These latter gages were located so that readings were obtained at the top, middle, and bottom of the members.

A temperature-compensating gage was mounted on a 2 x 2 x 6-in piece of Douglas fir and the lead wires from this gage hooked into the circuit of the 6-channel SR-4 bridge balance unit. In this manner one compensating gage served all of the active gages.

The joints were tested in the same manner as mentioned previously under "Shear Tests on Glued Joints", except that loading was interrupted at 5,000-lb intervals for purposes of making strain recordings.

Results of Strain-gage Tests. The results of the strain-gage tests are shown graphically in Figs. 12, 13, and 14. Fig. 12 and 13 show the distribution of strains along the glue line for various loadings applied to two different size joints. While the graphs show strain versus glue line lengths, it is possible to consider the curves as representing a qualitative view of the magnitude of the shears along the glue line. The reason for such an assumption is that the strain gages were actually attached to both the 1-in and 2-in members of the joint. As a result the strains recorded by the gages were the strains produced close to the glue line in both the 1-in and 2-in members. If it were not for the glue, the surfaces of the two members would slide past one another. Therefore, since the thin sections along the glue line moved together, slippage had to be resisted by shear forces in the glue line equal to the wood-fiber stresses on either side of the glued surfaces.

The ideal shear curve would appear similar to the 70,000-lb curve in Fig. 13. However, because of the variations in wood and the possibility that slight slippage between wood fibers occurred, most of the curves were somewhat erratic. Nevertheless the trend of the curves verified the photoelastic analysis in that shear stress is a maximum at the ends of the glue line and a minimum at the middle.

Fig. 14 shows the distribution of strain along the center lines of the 1-in and 2-in joint members for various loadings. The ordinate of the curves shows the strain readings from the top of the joint down. At each loading, therefore, it will be noticed that in the 2-in member the compressive strain is a maximum at the top and tapers to zero at the bottom. Just the reverse is true of the 1-in members. Such distribution is logical since it is to be expected that strain would be maximum at the loading points of both members.

It must be remembered that the strain curves of Fig. 14 represent the strains along the vertical center lines of the members and not across their entire section. It has already been shown that the strains in both members along the glue line are quite different than those in Fig. 14. The latter curves illustrate the rate at which one member transmits internal strains to the other member. It will be noticed that the maximum transfer of strain occurs at both ends of the glue line. As a result, the shearing forces in the glue line must be maximum at these points. Actually the difference in strain between the two members at any point gives an indication of the relative magnitude of the shear in the glue line at that point. Theoretically, then, the point where the 1-in and 2-in curves cross should be a point of zero shear in the glue line. Such a condition probably never occurs, however, because of slight slippage either in the glue line or in the wood fibers.

The erratic curve for the 2-in member at 20,000 lb load most likely is the result of the strain gage at the top of the member being defective or improperly bonded to the wood.

The shear pattern developed in glued joints explains the decrease in unit strength with an increase in length of joint. When length is added to a joint, glue area is added that never becomes stressed to its maximum; consequently unit strength decreases.

SUMMARY

The strength of a glued joint varies in direct proportion to its width. The strength of a glued joint does not, however, vary in direct proportion to its length. Due to eccentricity in the transfer of stresses from the center member through the outer members, the glue line is not subjected to pure shearing stresses but also to tensile stresses tending to pull the joint apart in a direction normal to the glue line. This in effect lowers the unit stress which compression joints are capable of carrying. In the series of joints described here- *(Continued on page 416)*

Effects of Drainage on Agricultural Production

By Lewis A. Jones
FELLOW ASAE

THE purpose of this paper is to call attention to the value of an intensive program of farm drainage in connection with the agricultural production job which faces this country today.

There is greater need for food and fiber production on United States farms today than ever before. The population of the United States has increased from 131.7 to 151.8 million in the 10 years from 1940 to 1950, and is continuing to increase at the rate of about 2 million a year. There has been an increase in per capita food consumption of about 12 per cent since 1940, due in large part to expanding consumer purchasing power.

An appreciable part of our food supplies must go to feed men in military service. It takes more food to feed such men than it does those in civilian life. In addition, military operations require larger reserves of food than are needed in normal civilian feeding. Our present exports require the production from approximately 50 million acres — one-seventh of the total of cultivated crops. There appears to be little prospect that these exports will be materially reduced in the near future.

As a result of these heavy demands, the agricultural surpluses we heard so much about a few years ago are now a myth. The supplies of such items as butter, cheese, dried milk, canned vegetables, and canned fruit held by the Commodity Credit Corporation have been reduced 50 per cent since the start of the Korean War, and are continuing to decline at a rapid rate. The cotton carry-over for 1952 is estimated at about 2 million bales, or but 12½ per cent of annual requirement. The corn carry-over for 1952 is estimated at 635 million bushels, or about 20 per cent of the annual requirement.

In this defense era, we are on thin ice unless we are carrying over corn reserves of 800 million to 1 billion bushels. Such a carry-over would give assurance of adequate and reasonable livestock feed to producers who must plan their operations in advance. It would also tend to stabilize meat prices.

The wheat carry-over for 1952 is estimated at 375 million bushels instead of the 500 million bushels considered desirable in case of a bad crop year, or for abnormal export in case of famine or crop failure in other wheat-exporting countries. At this very moment we are losing ground — we are consuming at a greater rate than we produced in 1950, and it appears that demands in 1952 will exceed our 1951 production.

To win the battle we need every ounce of production we can squeeze out. High-level production is the greatest contribution agriculture can make to price stability.

During the decade to 1950, farm output increased over 25 per cent while crop acreage increased only 3 per cent, and farm employment actually decreased 11 per cent. In addition to improved cultural practices, better crop varieties, and better livestock breeds, this achievement can be attributed primarily to four principal factors, namely, (1) increased use of mechanical equipment, (2) fertilizers, (3) pesticides, and (4) electricity. Mechanical equipment and farm electrification have materially reduced farm labor requirements, while increased use of fertilizers and pesticides have increased the per acre crop yields.

With population increase alone — 2 million more to feed each year — farm output simply must continue mounting if we are to maintain our present standards of living. Manifestly every effort should continue to be made to increase the mechanization of our agricultural production plant, to expand the use of fertilizers and pesticides, and to improve livestock breeds and crop varieties. However, other methods of increasing production should not be overlooked. This is where farm drainage enters the picture. Well-drained land increases the efficiency of the farm machinery and labor used in preparing, cultivating, and harvesting crops. It also increases the effectiveness of the fertilizers used, and improves plant growth.

Great damage to crops because of inadequate drainage is usually recognized but too often is considered unavoidable and coupled with it is the wishful thinking that next season will be more favorable. A poorly drained field, which in some seasons is partially productive and in others is not, is an expensive one to cultivate. When a field is plowed, planted, and cultivated and little or no crop is harvested, not only is the land unproductive, but the labor, fertilizer, and seed are wasted.

In speaking of farm drainage I am not proposing the reclamation for agricultural use of any of the millions of acres of swamp land still remaining in the country. Such work should be a part of a long-time program covering the development of the country's natural resources, with due consideration being given to wildlife, recreational, and other land-use possibilities.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1951, as a contribution of the Soil and Water Division.

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These two views illustrate the method used in installing Bowerston perforated drainage tile on the Charles Wood dairy farm in Lake County, Ohio. *(Left)* The tile is laid in the trough shown while the trailer is moving. This assures convenient placing of the tile on the ground prior to digging the trench. *(Right)* A Buckeye traction ditcher digs the trench, and the tile is immediately aligned in it by the workman, as shown.

What is proposed is the improvement of drainage on extensive areas of land now under cultivation — land on which crop yields are reduced practically every year due to poor drainage, and some years fail completely. The work required is limited primarily to the cleaning out and maintaining the existing outlet ditches, with new ditches required occasionally, and the improvement of field drainage, including field ditches, land grading, tile drains, etc.

During recent years the Soil Conservation Service has supplied many landowners in soil conservation districts with technical assistance in carrying out such work. The results obtained have been striking, and indicate the possibilities of such work in a program of "all out production." For instance, in 1946 the soil conservation district in Union County, Ky., assisted three landowners in improving the drainage on 148 acres of land at a cost of $2,730, or $18.40 per acre benefited. One of the landowners, A. L. Byrd, who had 58 acres of land benefited by the work states that before drainage the corn yield on his 58 acres averaged a scant 10 bu per acre; soybeans averaged about 10 bu per acre when he got a crop, but frequently the crop was a complete loss; while barley crops were seldom worth harvesting and never exceeded 15 bu per acre.

DRAINAGE COST OFFSET BY GREATER CROP RETURNS

Since drainage, corn crops have averaged 70 bu per acre, soybeans 20 bu per acre, and barley 25 bu per acre. Based on an increase of 50 bu of corn per acre, the 148 acres of drained land will produce 4,100 bu more corn each year than before drainage. At $1.50 per bu this increase would be worth $6,600 per year, which is more than twice the cost of the drainage improvements.

In 1947 a group of farmers located near Grifton in Pitt County, N. C., got together and dug a ditch about 5 miles long to serve as a drainage outlet for their land. Before the ditch was dug about 500 acres of this land was too wet to plant and 800 additional acres were very risky to cultivate. The ditch cost $19,664, or about $18 per acre for the land benefited.

Howard Rasberry, one of the farmers involved, states that he is now raising corn, soybeans, and tobacco on 150 acres of land that was too wet to crop before the ditch was dug. The land is now producing 80 bu of corn and 25 bu of soybeans per acre, a nice addition to productive capacity of the country.

M. B. Hodges, another of the group, states that he has 75 acres he tried to cultivate before drainage, but 40 per cent of the time the crops were a total loss, and the rest of the time he lost at least half the crops. Since the ditch was dug he has not lost a crop. He plants the 75 acres to corn, soybeans, oats, lespedeza, and tobacco. The average yields are corn, 50 bu per acre; soybeans, 25 bu per acre; oats, 60 to 75 bu per acre, and tobacco, $800 to $1,000 per acre. Mr. Hodges states that his part of the ditch cost him $3,250 and his increased yield has more than paid him that much each year. Here is a man who has more than doubled his production without increasing his expenditures for machinery, labor, or fertilizers.

"Chuck" Brandt has a farm in Rush River Township, Cass County, N. D. In 1937 he spent $3,500 in payment of his share of the cost of an outlet drainage ditch for his 500-acre farm, and in constructing field drains for the area. Prior to constructing the drainage improvements, 30 acres had always been to wet to cultivate, and crops on about 100 acres were frequently a complete loss because of poor drainage after heavy rains. Mr. Brandt states that none of the land could be farmed properly because it was too wet. He says the increased crop yield resulting from drainage was more than enough the first year to pay the cost of drainage, and that he now is getting better yields on the formerly wet land than from his higher land. He raises alfalfa, small grains, sugar beets, hogs, and sheep.

In 1947, Boyd White, a cooperator of the soil conservation district in Union County, Miss., improved the drainage on 50 acres of his land by constructing a small dragline outlet ditch about 1,000 ft long. The cost was approximately $3 per acre for the land benefited. During the 3 years prior to the construction of the ditch he averaged about one-third of a crop. The entire field overflowed and stayed wet for a long time after heavy rains. Since the completion of the ditch the field has averaged a bale of cotton to the acre. The crop years 1949 and 1950 were extremely wet, and Mr. White says, "If it hadn't been for the ditch I would have had crop failures."

It is possible to continue indefinitely relating specific instances where the improvement of farm drainage has very materially increased crop production, without bringing new land into cultivation, or requiring the use of additional farm equipment, farm labor, or fertilizers. In fact, well-drained land can generally be farmed more efficiently and with less labor and wear and tear on the equipment than was the case before drainage. In addition, fertilizer applied can be more effectively used by the crops on drained land.

There are no reliable figures available on the amount of land now being farmed that would be benefited by improved drainage. Experienced soils men estimate that about 20 per cent of the cultivated land in the humid section of the United States would be benefited by such work. They also call attention to the fact that the land that would be benefited by drainage is generally the most productive land available.

Based on the foregoing it would seem there are some 30 to 40 million acres of land now under cultivation on which crop yields could be increased 50 per cent or more by farm drainage work, an increase which can be obtained without increased demands for machinery, labor, seed, or fertilizer. All that would be required would be a limited amount of construction equipment such as small draglines, bulldozers, and graders. In view of the urgent need for increasing our food supply, it would seem that every effort should be made to provide the necessary critical materials to furnish and maintain the small amount of equipment necessary to carry on an expanded program of farm drainage.

It would seem also that the facilities of the Soil Conservation Service and other federal agricultural agencies; the local, well-organized soil conservation districts and drainage districts, and all other agencies engaged in working with the farmers could well afford to engage in a campaign to improve farm drainage conditions in these United States.

Strength of Glued Joints

(Continued from page 414)

in, maximum unit stresses were obtained from joints 3 in long.

As the length of the glued joint is increased, the unit strength decreases. The glue line is not stressed equally throughout its length. Greatest stresses occur at the ends. The longer the joint, the smaller the stresses at the middle as compared to the ends. The total strength increases as the length increases but the unit strength decreases. As a joint is lengthened, the total strength eventually reached the compressive capacity of the individual members, causing compressive failure in the members rather than destruction of the glued joint. In the tests herein described, this length proved to be about 8 in, although in a few cases compressive failure occurred at somewhat shorter lengths.

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Evapotranspiration Estimates as Criteria for Determining Time of Irrigation

By C. H. M. van Bavel and T. V. Wilson
ASSOC. MEMBER ASAE

ONE of the problems associated with irrigation in the more humid areas of the United States is that of determining when to start irrigating a crop. Various methods have been used but none have emerged as satisfactory, practical, and economical.

The object of irrigating is to prevent the tension of the soil water from reaching such a high value that plants are being appreciably depressed in growth, development, and ultimate yield. The magnitude of this threshold value for the various crops is, in most cases, still unknown. It is known that various plant functions do not take place independently of the soil moisture tension. Rate of transpiration, rate of exudation, elongation of leaves, and growth of whole plants have been shown to have a maximum somewhere in the low-tension range and then to decline gradually to a minimum at the wilting percentage.

In view of the preceding, one of the more important aspects of irrigation is to determine what the status of soil moisture conditions is at any given time. For this purpose, use can be made of the fact that for a given soil in the field, the value of the soil moisture tension is uniquely related to the soil moisture content; this relationship is known as the moisture characteristic of the soil. The fact that the moisture characteristic usually exhibits some measure of hysteresis may be disregarded for the purpose of this discussion. An example is shown in Fig. 1. In order then to determine in the field the time at which the moisture supply of the soil has been depleted by the plants to the point of maximum allowable tension (or the moisture percentage associated therewith) one must measure either tension or moisture percentage. On this subject a vast amount of work has been done by soil physicists and others during the last 30 years. This was done particularly in view of the practical difficulties of direct sampling of the soil.

As a result, there are now available tensiometers to measure the soil moisture tension directly, and gravimetric plugs, Bouyoucos gypsum blocks, nylon blocks, Colman fiber-glass blocks, thermal conductivity units, and other types of instruments which measure, indirectly, the soil moisture content from which the soil moisture tension can be derived.

Even when used in research work, these methods are expensive in purchase cost and in time required for operation and interpretation. For practical use by the farmer, they are all but out of the question. Moreover, there has been no single method developed which is satisfactory for field use. This is due mainly to the small soil volume which is measured by any of these methods and the resultant variation between replicate installations.

THE BASIS OF THE EVAPOTRANSPIRATION METHOD

A somewhat different approach to the problem of determining the status of soil moisture at any given time is the indirect means of accounting for differences between additions of water to the soil and losses of water from the soil. On drained land, water is lost by evaporation from the land surface and by transpiration of the vegetative cover. The combined process, known as evapotranspiration, accounts for all water losses while irrigation and rainfall minus runoff account for all additions. It follows that, if the quantities of water added to the soil were known and if the total daily evapotranspiration amounts were known, a simple bank account procedure could be used to determine the readily available supply of water in the soil at any time. When this supply appears to be reduced to zero, or nearly so, the need for irrigation is indicated.

The given idea for estimating soil moisture reserves and scheduling irrigation has been proposed earlier. Thornthwaite advanced this method in a paper in 1946 (9).* A similar proposal was made by Schofield (7) and by Penman (4, 5).

The use of the outlined principle entails two main sources of error. In the first place, it is not always easy to determine what proportion of rainfall infiltrates to replenish soil moisture, particularly in the case of high-intensity rainstorms. Fortunately, in the case of heavy rains exceeding the available water-storage capacity of the soil, runoff is oftentimes not too significant because it would represent surplus water, whether it entered the soil or not. However, there are some summer rains that fall at high intensities for short duration which, even on dry soils, exceed the maximum infiltration rate.

Secondly, one must have a reasonably accurate estimate of evapotranspiration losses. Considering the fact that such losses are determined by such variable factors as the radiant energy from the sun, the wind velocity, the temperature of the air, the relative humidity of the air, the temperature of the leaf or ground surface, and the density of cover, it seems that computing evapotranspiration might be a complicated process, the results of which have small general value. Actually, experience has shown, as will be discussed later, that evapotranspiration values computed from long-time averages of the cited meteorological factors have considerable validity. This is possibly due to the fact that the daily variations, if considered

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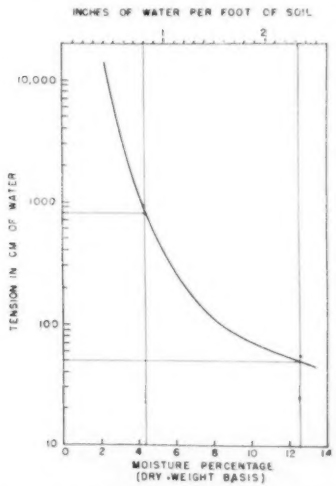

Fig. 1 The moisture characteristics of Ruston coarse sandy loam (desorption)

*Numbers in parentheses refer to the appended references.

over several days, very nearly cancel each other. It must also be remembered that the estimate of evapotranspiration need not be any more accurate than the other elements of the computation, such as the rainfall record, error due to runoff, and variable soil moisture characteristics.

Some formulas have been proposed for computing evapotranspiration. Penman (5) developed a formula which is valid for plants that cover the soil completely and are well supplied with water. It would apply, therefore, to full stands of grown crops that were kept well supplied with water by either rain or irrigation. The chief disadvantages to Penman's formula are that it is complicated and that one needs weather data that are found in only a relatively few places. This formula is based, however, on an exact theory and may be used as an independent check on values obtained otherwise.

An empirical formula which is based on latitude and average temperature of the air as the only variables is given by Thornthwaite (8, 10). This formula is easy to use as only temperature data are needed. Because it is empirical, Thornthwaite's formula also accounts for the fact that vegetative cover is not complete in the winter and spring. This formula could, therefore, be in error for tropical or subtropical areas where seasonal differences are not so great.

Another formula, proposed by Blaney and Criddle (1), is based on average monthly daytime hours and average monthly temperature. In addition to those two variables, their formula also makes use of a consumptive-use coefficient, which can be used to account for variations due to thickness of vegetation, stage of crop growth, and other crop variables. The derivation of the magnitude of these consumptive-use coefficients appears somewhat questionable.

In Fig 2 the monthly average evapotranspiration in Raleigh, N. C., is shown as calculated according to Blaney and Criddle, Penman, and Thornthwaite, together with some actually observed values under conditions where Penman's formula applies, namely, an open water surface at Chapel Hill, N. C., relatively close to Raleigh. The maximum difference between the formulas and observed values during the crop-growing season is 14 per cent, which occurs in June for Penman's formula and in July for Thornthwaite's formula†.

ACTUAL AND CALCULATED EVAPOTRANSPIRATION RATES

Considerable evidence has been collected by Thornthwaite and associates that actual evapotranspiration rates are in close agreement with the ones calculated, although they consider that the formula used could be further improved. Such evidence was obtained from soil moisture measurements (9) and also from modified lysimeters especially constructed for the purpose (11). The articles cited here give further reference to the extensive literature on evapotranspiration, its significance, and measurement. Further evidence in favor of Thornthwaite's formula was given by Harrold and Dreibelbis (2).

A recent study in Canada by Sanderson (6) showed also close agreement between measured and computed rates of evapotranspiration. This work shows that there is not a great difference between computations based on long-term averages of temperature and computations based on the actual occurring temperature. This has practical significance, because it is easier to use average figures computed in advance rather than work with current data.

Penman also found the use of his formula substantiated in experimental studies on lysimeters, drainage fields and watersheds (5, 4).

An important question is, whether the evapotranspiration of different crops is different under similar conditions. So far, provided an ample moisture supply is in the soil, few experimental data would support this view. More research should be done to explore this point. The work reported here is based on the assumption that a closed vegetative cover under equal meteorological conditions disposes of the soil water supply with equal rapidity, regardless of botanical composition.

†The lower observed values at Chapel Hill might be caused by the more moderate microclimate of the site of observation, being a small lake. Data were obtained in a Class A Evaporation Station by the U. S. Weather Bureau.

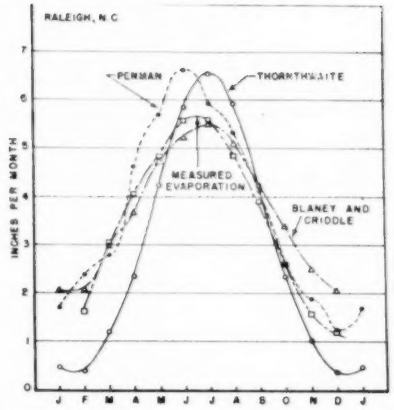

Fig. 2. Evapotranspiration in inches per month for Raleigh, N. C., as computed by three methods and as measured at Chapel Hill, N. C. In Blaney and Criddle a consumptive-use coefficient of 0.70 was used.

METHOD OF APPLICATION

The practical application can probably best be brought out by an example here arbitrarily taken to be a field of tobacco on Ruston coarse sandy loam at Raleigh, N. C., in July. The moisture characteristic of a Ruston coarse sandy loam shows that at field capacity (occurring at 50 cm tension) the moisture content is 12.5 per cent. If the maximum allowable tension is taken at 800 cm of water (unpublished data indicate this value, but its exact magnitude is not important for this discussion) the corresponding moisture content is 4.4 per cent. The maximum useful capacity is then 8.1 per cent and for a rooting depth of 12 in and a bulk density of 1.55, this represents 1.50 in of water.

According to Thornthwaite, the daily evapotranspiration for the Raleigh area is 0.21 in in July. Therefore, as indicated in Table 1, by subtracting evapotranspiration from the supply and by adding rainfall and irrigation to the supply, a running record of available soil moisture can be kept.

TABLE 1. Example of a Soil Moisture Account
Ruston coarse sandy loam

Volume weight, 1.55
Moisture content (weight basis) at field capacity = 12.5 per cent
Moisture content at maximum allowable tension = 4.4 per cent
Useful moisture range 8.1 per cent
Volume of water in useful range (12 in of soil) 1.50 in

Date	Evapotranspiration	Precipitation	Irrigation	Supply
July 1	0.21	1.80		1.50
2	0.21			1.29
3	0.21			1.08
4	0.21			0.87
5	0.21	0.26		0.92
6	0.21			0.71
7	0.21			0.50
8	0.21			0.29
9	0.21			0.08
10	0.21		1.50	1.37
11	0.21			1.16
12	0.21	1.06		1.50

When a need for irrigation is indicated as on July 10 in Table 1, 1.50 in should be applied. Rainfall is also added to the supply, except when the total exceeds 1.5 in. If 1.5 in is exceeded, the additional water is not added to the supply because it becomes unavailable to the plants by storage beyond the root zone or by drainage to the water table.

In order to use the evapotranspiration approach, the rooting depth of the crop, the moisture characteristic of the soil, the moisture-tension tolerance of *(Continued on page 420)*

Progress Toward Greater Safety in Agriculture

By C. L. Hamilton
MEMBER ASAE

AGRICULTURE is steadily making progress toward mobilizing the resources and forces required for the farm safety job. There is some work under way in practically all states. About one-half of the states now have state farm safety committees to initiate teamwork and correlate the efforts of interested state agencies. About a dozen of the states with the most active programs have one or more full-time farm safety specialists on the job. County farm safety committees are already at work in many communities and an impressive number of special farm safety educational campaigns are now under way.

Industries interested in agriculture and other agencies, as well as the farm radio and press, are adding increasing support to the movement. We are particularly indebted to the farm equipment industry for their splendid cooperation, not only in connection with the educational and financial problems but also for their contributions to accident prevention research.

In the comparatively short time we have been concentrating on farm safety, we have learned a lot. We now have a clearer picture of what will be necessary to start the national farm accident curve downward and keep it falling. We know now that farm safety is more than a sideline or part-time job. It involves a lot more than just warning people to be careful. We know that farm accidents can be reduced, but this cannot be achieved with scattered or indifferent activities. We must all develop a much broader concept of the job involved and the scope of the remedies required.

The farmers across the country did not become soil conservation or rural electrification conscious in a year or two, or by merely hearing speeches and radio programs or reading magazine articles. Besides publicity it required, thousands and thousands of demonstrations, extensive research in every state, hundreds of well-trained technicians in the field, and finally a small army of rural leaders organized into strong associations and governing bodies to direct community programs.

Visualize the job of farm safety in the same magnitude as you now see soil conservation. Add to this the fact that it is much harder to work with people than with soils or tillage practices, and you will have a better picture of farm safety in the years ahead. I do not believe we will ever achieve real safety on the farm until we have every rural community organized and voluntarily working on their local safety problems. People learn by doing, and safety is no exception. It is going to take many unique projects and much participation and organization. Each community must have leaders to supervise and direct their own program to meet their local needs.

The movement has sprouted from sound roots and it is bound to grow and develop because no one can oppose it conscientiously. The only limitation of progress will be the funds, personnel, and other facilities that can be applied to the cause. The big challenge before agriculture is whether the record made in industrial safety can be equalled or exceeded in farming. We believe it can be done, and we hope on a voluntary basis, without a huge government appropriation and associated state or federal regulations. States that have tried to regiment farm safety through legislation and enforcement have had an unhappy experience.

RESEARCH AGAINST HUMAN CARELESSNESS

Besides the education and execution job, there is a big research field in farm safety. As yet very few farm leaders think of safety in terms of research. This phase of the job is still in the embryo stage.

First of all, we need much more complete and extensive statistics on farm accidents, which show the extent, type and cause in any state or community. This information will guide program needs, indicate remedies and serve as a yardstick for measuring accomplishments. Until arrangements can be made to secure periodic farm accident information through regular state or national agricultural census channels, it will be necessary to depend on informal surveys by organized groups, newspaper clippings, or similar sources.

One of the most challenging jobs for agricultural engineers will be in the research field or in the development of basic criteria for educational activities. Furthermore, the major portion of the work ahead in farm safety research will fall in the field of agricultural engineering. It should be one of the most interesting and satisfying phases of the job. It is much easier to secure application and acceptance by offering new and better ways of doing hazardous farm jobs. Too many of our present farm safety recommendations are based on opinions, traditions or assumptions with no real research to back them up. Many are used in the absence of something better. Sound criteria from engineering studies or analysis of hazardous farm jobs is needed badly to keep the safety movement on a healthy, progressive footing.

Much of the farm safety research will involve on-the-spot analysis of hazardous farm jobs. If it is possible to eliminate or reduce a hazard by changing routines, relocation, guarding or substituting one thing for another, that makes the educational job much easier, more interesting and acceptable. For-

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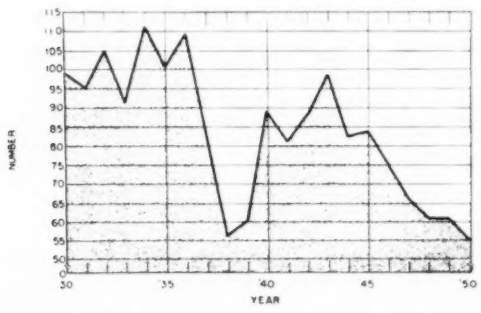
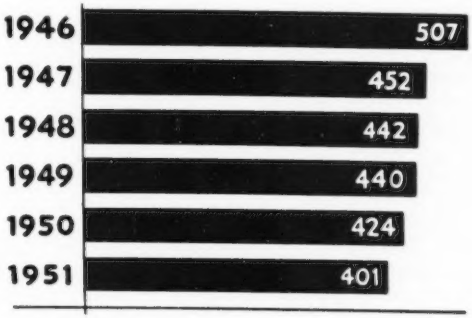
The author: C. L. HAMILTON, assistant director and agricultural engineer, farm division, National Safety Council, Chicago, Ill.





(Left) This graph of the total of fatal farm work accidents in Kansas reveals an encouraging trend over a 21-year period. Since the close of World War II the state has employed a full-time, farm-safety specialist. *(Right)* This is Ohio's record of all types of accidents to farm people since an intensive state program was started and a full-time, farm-safety specialist employed in 1945.

tunately, the development of safer ways of doing farm jobs often goes hand in hand with easier and cheaper methods. This approach is not only basic for faulty mechanical or physical conditions, but it also provides the surest remedy for accidents arising out of unsafe personal habits or practices.

Standardizing the tractor power take-off and providing uniform shielding is a good example. Besides making it harder to have an accident, it was a convenience to manufacturers and the farmer by reducing the number of parts and hitches required. After several years of repeated warnings, however, farmers still left their shields off. Further "engineering against human carelessness" was needed and provided through a non-removable shield which most of the implement companies put in production about a year ago.

Let us not forget the pattern set in solving the old electric fence problem. I doubt if we could have made much progress if we had relied entirely upon education — just warning people to stay away from charged fences." The problem was analyzed, research was conducted to determine the current a person could endure safely, and subsequent standards were established to guide the manufacturer of electric fence controllers. The use of homemade units was discouraged and electric fence tragedies dropped rapidly.

The use of self-starters on tractors instead of cranks, streamlining and enclosing or guarding of gears, belts and chains are other examples of engineered safety. You may not realize it, but the mechanization of manure and hay handling will show safety dividends through the elimination of another troublesome farm hazard — the common pitchfork. Even the introduction of hydraulic controls has helped reduce some of the hazards in operating farm machinery.

STANDARD HIGHWAY WARNINGS GREATLY NEEDED

Tractor traffic accidents are increasing with the increased use of tractors on highways. Rear-end collisions predominate, due to inadequate lighting and warning of slow-moving vehicles. Recently a special committee of engineers from the implement industry was set up to develop standard warnings and lighting for farm equipment on highways. Progress has been slow because of conflicting state traffic laws, but the last committee's report indicated that their final recommendations and equipment will soon be available. Although tractors introduce new farm hazards, we have evidence to indicate that they may not be as serious as what we used to have with horses and mules.

We are all familiar with the unsolved corn picker problem. Every harvest takes a heavy toll of fingers, hands, arms, legs and lives, year after year in corn belt states. We need something better than just repeated warnings "to shut off the power before unclogging corn pickers." A real solution is long overdue. If we are unable to design a corn picker that will not clog up, perhaps we can develop some safe method of unclogging, so it will not be necessary to do it by hand. We are pleased that the farm equipment industry has a committee at work on this problem making field observations of several experimental possibilities.

Safety problems waiting solution are not limited to the farm machinery field. We have thousands and thousands of farm structures all across the country with built-in accident traps. Some time ago I checked nearly 100 barns in a good farming section, and I could not find a safely constructed haymow ladder to photograph for an illustration we needed. I also failed to find one shown in any of the college bulletins or building plans that I was able to check. The customary procedure and equipment used by farmers for hanging tobacco in tobacco barns would not be tolerated in an industrial manufacturing plant.

Protection against human carelessness must be designed into every day farm work, living, structures and equipment, the same as it is being designed into modern factories and highways. Accident prevention must be completely dovetailed into farming operations so it becomes an inseparable part of the job. Too often we make ourselves believe that it is just a problem of getting people to be more careful. We must change our thinking and devise ways that make it really difficult for farm people to have accidents.

Determining Time of Irrigation

(Continued from page 418)

the crop, evapotranspiration rates, and a record of rainfall will have to be known. All figures except the latter could be made available through the agricultural extension service after the necessary inquiries were made by the agricultural experiment station. Individual farm operators would have to measure rainfall and keep their daily soil moisture balance sheet.

SOME RESULTS OF APPLICATION AND CONCLUSION

In 1950 in an irrigation experiment conducted by the authors at Raleigh, N. C., irrigation was scheduled on the basis of the readings of mercury tensiometers placed in the plots. In Table 2, the dates of irrigation based on tensiometer readings are given along with the dates on which irrigation should have taken place if evapotranspiration estimates had been used. The agreement is very good, showing that the dates could have been obtained without tensiometers or other instrumentation which is now considered necessary to measure soil moisture tension. The same experiment repeated in 1951 gave the results given also in Table 2. The conclusions remain the same.

TABLE 2. Dates for irrigation as determined for a field experiment by tensiometer readings. Computed dates from estimated values of evapotranspiration.

1950		1951	
Actual	Computed	Actual	Computed
July 21	July 22	June 2	June 1
August 3	August 2	June 19	June 14
August 9	August 9	June 26	June 25
		July 2	July 3
		July 9	July 10
		July 14	July 15
		July 25	July 26

The computed values in Table 2 were obtained by using long-time averages of evapotranspiration, no corrections being made for actual weather conditions, development stage of the crop, runoff, and other variable factors. Yet this rough approximation gives accuracy which needs no improvement from a practical point of view. It is implied here that the tensiometers gave correct values.

For purposes of rationalization of irrigation practices the possibilities of estimating soil moisture content through evapotranspiration and measurement of rainfall should be evident. Furthermore, the simplicity of this system makes it mandatory that its possibilities be fully explored. It is not proposed that adequate proof is supplied in favor of the evapotranspiration method; however, data available to date are favorable and indicate that considerably more research should be done to determine its usefulness on different crops, soils, and areas.

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Harvesting and Conditioning Grain for Storage

By L. W. Hurlbut, G. M. Petersen, F. D. Yung, and E. A. Olson
MEMBER ASAE MEMBER ASAE MEMBER ASAE

THE ideal grain storage is one which will perfectly preserve ripe grain harvested under any condition. The ideal harvest time coincides with the time of ripening. These ideals have long been in the minds of grain producers and agricultural engineers, but many developments will be required before they can be realized. Each new development, though it may not reach perfection, becomes an important step toward the final goal.

Grain producers have always been reluctant to let their grain crops stand in the field until they have dried naturally to a moisture content safe for storage. They have made use of the header, the binder, the swather, and the corn crib as intermediate steps in their efforts to reap crops at the earliest possible time. These intermediate harvesting measures, and the lack of a continuous and easily controlled source of power on the farmstead, apparently have not been conducive to the development of equipment and structures suitable for curing the crops after they have been placed in bulk storage. However, these measures do indicate that the grower considers an early harvest of considerable economic importance.

The main advantages of artificially drying grain, compared to natural drying, are an earlier and more efficient harvest, a more favorable marketing price, and a product of assured quality at the end of the storage period. The best equipment for doing this job is that which will serve effectively and economically each year in handling a normal crop subject to normal weather conditions.

PURPOSE OF EXPERIMENTS

The idea of using forced unheated air for crop drying is not new. It was apparently conceived at the time that the harvester-thresher came into general use about 27 years ago. Duffee (1),* Lehmann (2), Aspenwall (3), Budgett (4), and Wooley (5) were among the first to report investigations considering the use of unheated forced air for drying small grains, shelled corn, ear corn, and soybeans. Since then Ward (6), Kelly (7), Shier, Miller, and Junnila (8), Shedd (9), Barre (10), and Fenton (11) have reported investigations with mechanical ventilation, or closely related studies involving natural ventilation, of high-moisture grain or ear corn in storage. The history of this method of drying consists of reports ranging from success to failure. The reports of success or limited success are generally tempered by an expression of doubt that forced unheated air would be satisfactory under some assumed unfavorable weather conditions.

Favorable reports made by Lehmann (2) and Ward (6) on ear corn, and by Shier et al (8), Fenton (11) and Duffee (1), indicate that this method of curing grain crops in bulk storage might serve very well for the farmers in Nebraska and neighboring states. The wide distribution of electric power and the normal abundance of relatively warm dry air are two factors of considerable importance in this method of drying crops.

The problem of removing excess moisture from stored grain can be explained fundamentally from the standpoint of vapor pressures, according to Barre (10) and Fenton (11). In order to dry grain effectively with forced ventilation, the two following conditions must exist:

1 Temperature and moisture of the outside air, with relation to that of the grain kernels, must be such that the vapor pressure in the air which is made to flow into the grain is lower than the vapor pressure within the kernels of grain.

2 The movement of air through a layer of the grain must be rapid enough to maintain some vapor-pressure difference if drying is to continue throughout that layer.

The relative temperatures of the grain and air seem to be of about as much importance as the moisture content of the grain or the relative humidity of the air since vapor pressures of the air and kernels are influenced by temperature as well as moisture level. The effect of temperature differences between the grain and the forced air has been observed, however they

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*Numbers in parentheses refer to the appended references.

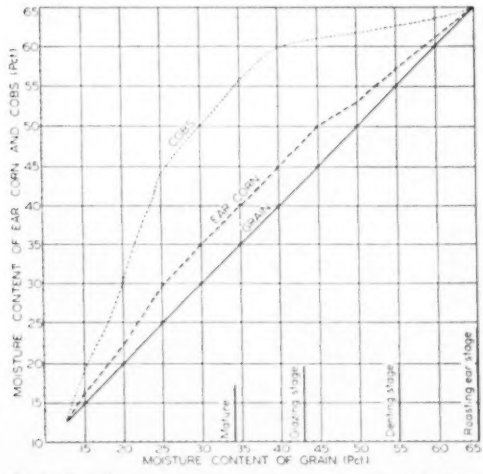

Fig. 1 Typical moisture percentages of ear corn, grain, and cobs at time of harvest, ranging from the roasting ear stage through maturity and to an air-dry condition (Nebr. Res. Bul. 166)

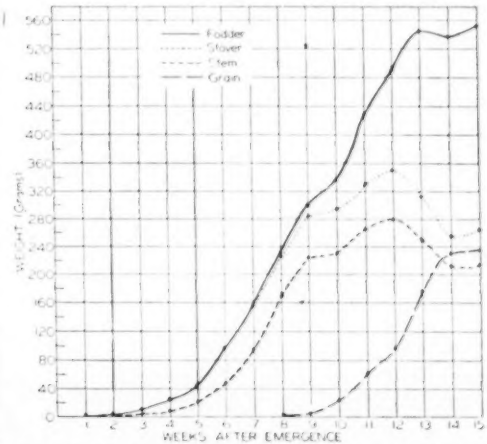

Fig. 2 Weekly changes in the mean moisture-free weights of fodder, stover, stem (without leaves), and grain of corn plants (White Prize variety) growing under favorable field conditions in eastern Nebraska (Nebr. Res. Bul. 166)

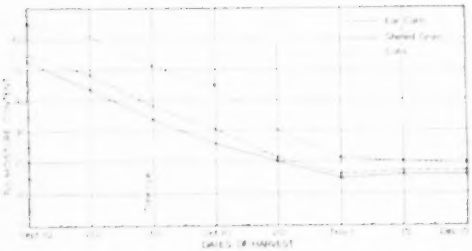

FIG. 1. Mean drying rates of ear corn, shelled grain, and cobs of two standard varieties planted at a medium date (May 17) and left standing unharvested in the field throughout the fall (Nebr. Res. Bul. 166).

cannot be measured easily in practice. But any temperature difference occurring within a mass of grain is conducive to moisture migration. This latter fact also establishes the need for periodically equalizing air and grain temperatures in bins of grain stored over a period of time encompassing important variations in atmospheric temperature.

The chief purpose of the Nebraska experiments is to correlate the advantages of an earlier, or less interrupted, harvest with practical methods of curing the grain subsequent to harvest. Work thus far has been done with existing harvesting machines and unheated forced air for curing the crop. Unheated forced air was chosen as the drying medium with the object of determining, first, its inherent limitations and, second, the most practical ways and means of eliminating or reducing any limitations found. High-moisture small grains, grass seed, legume seed and corn have been harvested and subsequently cured by this means in bulk storage. Factors considered in this investigation include kind of grain and initial moisture content, temperatures of the grain in storage, quantity of air, quality of the air, and the development of microorganisms.

AGRONOMIC AND PATHOLOGICAL FACTORS

The problem of harvesting and drying grain containing more moisture than is permissible for safe, long-time storage is bounded by agronomic factors governing the time of harvest, and by pathologic factors governing the environment in storage. Basic factors to be considered in addition to maturity of the grain and character of the air available are moisture and temperature of the grain, soundness of the kernels, foreign material present, and the period of time suitable for drying.

From the agronomic standpoint, the normal life cycle of a kernel of grain contains at least two periods which are of particular significance to the agricultural engineer. The first period is the one during which the kernel is formed. In the second period there occurs a gradual lowering of the moisture content to a point of equilibrium with that of the atmosphere (Fig. 1). The former involves an intensive biological activity which causes the grain to grow to full size within a space of a few weeks. Kiesselbach (21) reports that the development of a corn ear requires about ten weeks. The development of a corn kernel at weekly intervals until ripe is shown graphically in Fig. 2. The seed viability was found to be 95 per cent when corn was harvested and cured as early as two weeks before maturity and 65 per cent five weeks before it was ripe. Physiologic maturity is reached when there is no further translocation of substance from the stalk to the grain. The moisture content of the kernels at this stage is near 34 per cent, the cob near 54 per cent, and the entire ear about 38 per cent. Following maturity the change is mainly in moisture content which, under normal field conditions in eastern Nebraska, decreases at the average rate of about $\frac{1}{2}$ per cent per day (Fig. 3). By the time the kernels have dried to 12 per cent moisture, they, and the ever present fungi, are essentially at complete rest. A mass of stored grain includes living organisms subject to stimulation by excess moisture and temperature.

The various grain and seed crops differ slightly in moisture content at the time of ripening and in critical moisture limit for safe storage. But, in general, most starchy grains reach their maximum yield of dry matter at about 34 per cent moisture and the moisture limit for safe long-time storage is near 12 per cent. This means that there is a difference of about 22 per cent moisture between grain that is ripe and grain that is dry enough for safe storage in shelled or threshed form.

From the pathological standpoint, excess moisture is the major factor influencing mold growth in stored grain, according to Quisenberry (19) and Christensen (20). The growth of mold is also influenced by temperature, but not to the extent that it is affected by moisture. Extensive research has proved that molds are a primary cause of heating in stored grain. On the other hand, molds may grow so slowly in grain as to produce no detectable heating and yet make the grain unfit for food. McCall (11) reported such a condition as this in wheat in 1924, and referred to it as "sick wheat." The apparent effects of mold are reduced viability, and off odors and flavors in products made from the grain. This gradual deterioration from internal mold growth, which invades the germ, may be causing more extensive damage than the more obvious external molds.

The critical moisture content for stored grain is not a single fixed level, even for a single kind of grain, because mold growth is influenced by temperature, time in storage, and cleanness and soundness of the kernels. A moisture content of 11 to 13 per cent in oily seeds and 14 to 16 per cent in starchy seeds is sufficient to sustain some mold growth. Conditions favorable to mold growth are also favorable to insect reproduction in some grains and seeds.

Temperatures near freezing will slow the growth of molds but mold growth continues at temperatures as low as 20 F, and as high as 120 F, according to Christensen (20).

The basic agronomic, pathologic, and meteorologic relationships establish boundaries for the design work to be done by the agricultural engineer. Since these factors are not always compatible at the optimum time for harvest, the engineer has the choice of being satisfied short of the ideal or introducing necessary corrective factors in his attempt to provide the conditions necessary for the long-time storage of grain.

PRACTICAL LIMITS FOR PRESENT MACHINES

Field tests conducted at the University of Nebraska during the period 1948 to 1951 have demonstrated that the present-day combines and corn shellers will do a reasonably good job of harvesting oats, wheat, brome grass, legumes, and corn containing up to 25 per cent moisture. Wheat has been combined at 28 per cent moisture; oats, brome grass, and sweet clover at 32 per cent moisture, and corn containing up to 30 per cent moisture has been picked and shelled with an improvised trailer-mounted sheller.

Harold Hummel, a farmer near Fairbury, combined a 3-acre field of brome grass mixed with alfalfa, which yielded

FIG. 4. Trailer equipped with air distribution system adequate for drying grass and legume seed with unheated forced air. This equipment is used by Harold Hummel.

seed containing about 51 per cent moisture. The seed from another 5-acre field was harvested at 46 per cent moisture. About 200 bu of this seed was dried to 12.2 per cent moisture in 84 hr of fan operation spread over a period of 10 days. The seed was dried in a specially adapted trailerbed (Fig. 4) connected to a fan which supplied forced unheated air. Later the same month, Mr. Hummel combined 15 acres of sweet clover seed which yielded a total of 90 bu of clean, dried seed. The depth of dry clover seed in the trailer was measured at 19 in after it had been reduced from 23.2 to 10.8 per cent moisture in 109 hr of fan operation. The dry brome grass and clover seed tested 88 and 97 per cent germination, respectively.

Theodore Wirth, a large-scale farmer near Nebraska City, has shelled corn at 35 per cent moisture in a commercial type sheller. He depends upon heated air for drying the grain.

Experiences and observations in Nebraska confirm brief but early reports made by Duffee (1), Miller (13), Aspenwall (3), McGregor (12), and Logan (18), indicating that existing harvester-threshers and corn shellers could harvest grains and soybeans when the moisture content was well above the limits for safe storage. These reports also serve to emphasize the difficulty involved in determining the proper time to commence the harvest when the crop has to be stored in existing structures.

The fluctuation of moisture in small grains during the harvest season is another factor of considerable importance. It may be quite large and is sometimes changed quite rapidly. Goss (15) reported that the moisture content of oats, after a heavy dew, dropped from 20.4 per cent at 9:00 a.m. to 11.4 per cent at 11:00 a.m. Cromer, Cobb, and Josephson (16) reported on wheat with variations in moisture content ranging from 3 to 8.3 per cent in one day. Fenton (11) reported a case where wheat, at Manhattan, Kans., lost 26.1 per cent moisture (35.5 to 9.4 per cent) in five days.

DRYING WITH UNHEATED FORCED AIR

Members of the department of agricultural engineering at the University of Nebraska now have three years' experience with both farm demonstrations and laboratory tests where forced unheated air has served successfully for drying high-moisture wheat, oats, shelled corn, and brome grass. Clover seed has been dried successfully for the past two years. Tests have been made with both small and large volumes of corn, wheat, and oats, containing up to 24 per cent moisture. Grain at this moisture level was dried in tight bins with grain depths limited to 6 ft measured above the lower edge of the lateral ducts, and air was supplied at the rate of 3 cfm per bu, continuously. The experimental bins were filled in one day. Brome grass and clover seed have been handled at more than 25 per cent moisture but this was done in smaller batches and with considerably less depth of seed.

In 1951, an experimental duct system placed 18 in above the floor was tried in three bins 8 ft deep. A schematic diagram

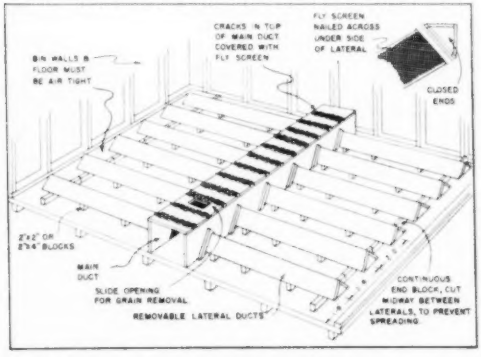
CRACKS IN TOP OF MAIN DUCT COVERED WITH FLY SCREEN
FLY SCREEN NAILED ACROSS UNDER SIDE OF LATERAL
BIN WALLS & FLOOR MUST BE AIR TIGHT
CLOSED ENDS
2"x2" OR 2"x4" BLOCKS
MAIN DUCT
SLIDE OPENING FOR GRAIN REMOVAL
REMOVABLE LATERAL DUCTS
CONTINUOUS END BLOCK, CUT MIDWAY BETWEEN LATERALS, TO PREVENT SPREADING

Fig. 6. Schematic diagram for adapting the floor of an existing grain bin for forced-air ventilation

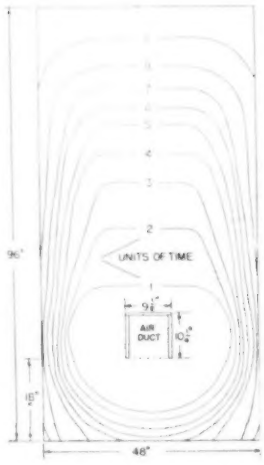

Fig. 5. A schematic diagram showing progressive drying in a 100-bu experimental bin. Drying medium was unheated forced air

of progressive drying in these bins is shown in Fig. 5. Wheat was placed in these bins at 21 to 24 per cent moisture and dried to 12 per cent moisture in about two weeks time. The cost was approximately 1½¢ per bu, at a power rate of 2¢ per kw-hr, for supplying 3 cfm of air per bushel continuously.

In order to make conditions more severe than normal, the circulation of air around the bins was somewhat restricted so that the humidity of the air was maintained between 50 and 70 per cent most of the time. The grain went into the bin at about 90 F but cooled to near 75 F until the inner layers became progressively dry, at which time the temperature of the grain became the same as the temperature of the incoming air.

The same elevated-duct system was used for drying shelled corn. The corn was placed in the bins at 26 and 30 per cent moisture on October 19 and 20, and was dried to 12 per cent moisture in periods of 30 and 42 days, respectively. The power cost was about 3 and 4¢ per bu, respectively, for supplying 3 cfm per bu continuously. The grain put into storage was neither exceptionally clean nor sound because the small sheller damaged some of the corn and it was not very effective in removing chaff and pieces of cob. An attempt was made to screen out some of the remaining chaff and badly shattered kernels before the grain was placed in the bin but this was only partly successful.

Nebraska farmers have already dried thousands of bushels of corn, oats, and wheat successfully with unheated forced air. The number of such farm installations has grown from 17 in 1949, involving approximately 17,000 bu, to an estimated 135 installations in 1950. The farmers who have tried drying crops with unheated forced air are recommending this method to others.

THE AIR DISTRIBUTION SYSTEM

A schematic diagram summarizing present recommendations for adapting the floor and walls of a bin for drying is shown in Fig. 6. The following is a summary of present recommendations:

1 *For the bin.* The bin wall and floor should be airtight. (A paper lining is sometimes necessary.) The depth of high moisture (25 per cent) oats, corn, and wheat should be limited to 6 ft measured above the lower edge of the lateral ducts. An outlet should be provided for the exhaust air approximately two times the size of the main duct cross section and located so as to prevent recirculation of the moist air.

2 *For the blower.* The blower should be capable of producing a flow of air in cubic feet per minute equal to three times the bushels of grain stored, against a static pressure of 2.5 in of water. The backward-curved centrifugal blower, as well as some of the newer propeller types, serves very well for farm use. Fans should be selected only on the basis of data published by the manufacturers. The ASAE Engineering Data on Grain Storage (23) show the pressures that are required to force air through different kinds of grain and through different depths of grain.

3 *For main duct.* A minimum cross-sectional area of 1 sq ft for each 1000 cfm of air flow is recommended. It is sometimes desirable to build the main duct in sections for easy removal

when the bin is being cleaned. The duct can be located in the center of the bin or along one side of it.

4. *For lateral ducts.* These are spaced 2 ft apart near the floor. The laterals may be slipped under cleats placed around screened openings in the main duct. It is advisable to place screen on the open side of the lateral. Successful experiments have been conducted with ducts raised 18 in. above the bin floor and spaced 4 ft on centers.

GENERAL ECONOMIC IMPORTANCE OF DRYING

A knowledge of the results obtained with the customary methods of harvesting and storing grain is essential in establishing the economic gain obtained from any changes being considered.

Fenton and Swanson (11) (1932) report that replies received from 297 farmers indicated that 60 per cent had suffered damage to wheat in farm storage. The average amount damaged per farm was reported to be 1000 bu. These data include the year 1928 when a large amount of damage occurred. Considering the four-year period 1927 to 1930, the amount of wheat arriving at terminal markets unfit for milling varied from one bushel in eight in the years with favorable harvest weather to one bushel in four in the unfavorable years. While this grain is not a complete loss, it is subject to a substantial discount.

James W. Lemley (25), commodity loan supervisor, Nebraska Production and Marketing Administration Office, says that of 10,087 bins of farm-stored wheat sampled in 1950, 1190 were declared ineligible at the outset because of excess moisture, sprouts, or sick wheat. At a reinspection in November and December, 334 loans on bins which contained wheat near 15.5 per cent moisture were called up for cash payment because the grain was going out of condition. This indicates that about 15 per cent of the wheat went into the bin at a moisture level too high for safe storage. It is not uncommon for growers to store only the driest wheat harvested. Therefore, it can be assumed that more than 15 per cent of the wheat was harvested at a moisture level above the limit for safe storage.

The losses of corn occurring in the field and in storage are of considerable economic importance. When ear corn reaches the level of moisture safe for cribbing, the "normal" field losses, consisting of shelled corn and ears dropped, increase at a rate of about three per cent per week for a period of about four weeks, with the loss thereafter increasing at a rate of about one per cent per week. The normal loss at the earliest safe cribbing time seems to be near three per cent. The expected grain losses, under favorable harvesting conditions, are shown in relation to kernel and cob moisture content of ear corn. Table 1 is based on data reported by Shedd (9), Smith et al (22), and Kiesselbach (21), and unpublished data recorded by Amos and Hurlbut of the University of Nebraska.

TABLE 1. Expected Total Field Loss (Per Cent) of Corn Harvested Under Favorable Conditions in Relation to Moisture Content of the Kernels and Cobs

	Days after maturity						
Crop characteristics	Mature	10	20	27	34	41	49
Kernel moisture	34	26	20*	17.5	16	15	15
Cob moisture	54	46	30	24	21	19	17
Expected crop loss	1	2	3	6	9	12	14

*Normal harvest starts at a kernel moisture of 20 per cent.

The data in Table 1 indicate that harvesting losses may be more closely related to cob moisture than to kernel moisture. Furthermore, the data show that where provisions are made for a distinctly earlier harvest, a period of harvest with relatively low field loss at the beginning of the season can be substituted for a period of greater loss later in the season.

The amount of damage that occurs to ear corn in storage is not easily determined because of the large variation in results obtained in different years. Shedd (9) (1946) studied the effect of moisture content on grades of corn in crib storage during the period 1937 to 1946. He found that the percentage of cribs containing corn with 20.1 per cent moisture or less varied from year to year as follows: 1937-38, 90 per cent; 1938, 100 per cent; 1940-41, 89 per cent; 1941-42, 85 per cent; 1944-45, 55 per cent; and 1945-46, 19 per cent. He observed that it is under favorable conditions only that a moisture level of 20 per cent will insure the production of grade No. 1 or No. 2 by the customary methods of crib storage. The corn stored at 20 per cent moisture or less, in the 360 cribs observed, graded as follows (on a damage basis only): No. 1, 36 per cent; No. 2, 26 per cent; No. 3, 14 per cent; No. 4, 12 per cent; No. 5, 6 per cent; and sample grade, 6 per cent. Loss of some of the original good quality of ear corn subsequent to harvest results from a lack of ventilation. Poor ventilation may be caused by imperfect machine husking as well as imperfect storage structures.

Field and storage losses in the production of grasses and legumes are recognized as being rather high. The importance of field losses is contained in a report by Grandfield (17) who reported the yield of alfalfa obtained by hand harvesting and threshing compared to farm methods of harvest. He found that the present farm methods of harvesting lost about 35 per cent of the seed. On the other hand, Hanson and Harrison (24) of the Michigan Agricultural Experiment Station reports that with present harvesting methods farmers save only about 40 per cent of the alfalfa seed actually produced.

The foregoing data clearly indicate that a large economic gain can be made by improvement in grain harvesting equipment and practices and in the proper conditioning of grain for storage. The relatively simple method of drying grain with unheated forced air appears to be one of the "missing links" that farmers over a wide territory have been looking for to complete their successful mechanization of grain and seed production.

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(Continued on page 425)

INSTRUMENTATION AND CONTROLS

This section is sponsored by the ASAE Committee on Instrumentation and Controls. Contribution of short articles describing interesting instruments or instrument applications to agriculture will be welcomed, and should be sent direct to the editor of the section, Karl H. Norris, Agricultural Engineering Laboratory, Agricultural Research Center, Beltsville, Md.

The Cornell Soil Penetrometer

By C. W. Terry and H. M. Wilson
MEMBER ASAE

EXCESSIVE soil compaction has a deleterious effect on crop yields and may be a factor in accelerated erosion. Penetrometers are used in research work to determine the degree of soil compaction and have been found to be satisfactory for that purpose. Since the problem of soil compaction is causing considerable concern, it was thought the matter should be brought to the attention of farmers. Therefore, it was decided that a soil penetrometer could be used in extension teaching to demonstrate where soil compaction exists, the conditions that cause it, and what can be done to correct these conditions.

However, no penetrometer could be found that was entirely satisfactory for use in extension teaching. Some require calculations to determine results and so have no mass appeal. Others appeared to be complicated and costly to construct.

So it was decided to build a self-recording unit that could be demonstrated to groups, would be accurate, require no adjusting, be simple to build and easily transported. The penetrometer which is described in the following paragraphs meets these specifications and has proved to be a useful tool in extension teaching.

Principle of Operation. The construction of the device is such that the indicating or recording pointer is positioned by (1) depth of penetration of the point and (2) the downward force required to overcome resistance to penetration. Thus, as the point is pushed into the ground, a curve is drawn which shows force vs. penetration from the surface of the ground to the maximum depth of penetration (or until the limit of the force-measuring spring is reached).

The mechanism consists of two parts: (1) depth-measuring element and (2) force-measuring element.

To measure the depth of penetration, the chart board is supported on a foot which rests on top of the ground, while a pointer, attached to the probe, moves down a distance equal to the depth of penetration (Fig. 1a). This appears as the x, or abscissa displacement on the chart (after the latter is removed from the chart board).

The force measurement is based on the fact that deflection of a spring is directly proportional to the force applied. Force is applied to the probe through a spring, as shown in Fig. 1b. Deflection of the spring is measured by a suitable multiplying mechanism attached to the member to which the force is applied and to the probe itself. This deflection moves the pointer at right angles to that described above.

These two mechanisms are combined into one so that the two motions of the pointer occur simultaneously and draw the graph of force vs. depth of penetration directly on the chart.

For preliminary work and tests, the probe point shown in Fig. 1c, was made in the shape of a 30-deg cone with a tip radius of 0.010 in and a maximum diameter of 0.504 in which gives a maximum projected area of 0.20 sq in. This point was screwed into the end of the 7/16-in-diameter rod, through which the force was applied.

The force calibration was made by applying the force in the normal manner with the point bearing on a pair of platform scales. Deflections of the pointer were marked on the chart for each 10-lb increment of force.

The weight of the apparatus is about 15 lb. Only a few seconds are required to push the probe into the ground and obtain a trace. Generally, several tests can be made on the same chart without confusing the individual traces.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors: C. W. TERRY, agricultural engineering department, and H. M. WILSON, agronomy department, Cornell University, Ithaca, N. Y.

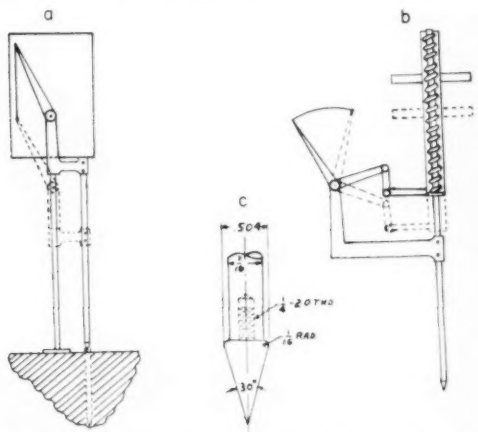

Fig. 1. Sketch of soil penetrometer. (a) Arrangement for plotting of the distance penetrated into the soil. (b) Arrangement for plotting the force required to secure the penetration. (c) Probe point.

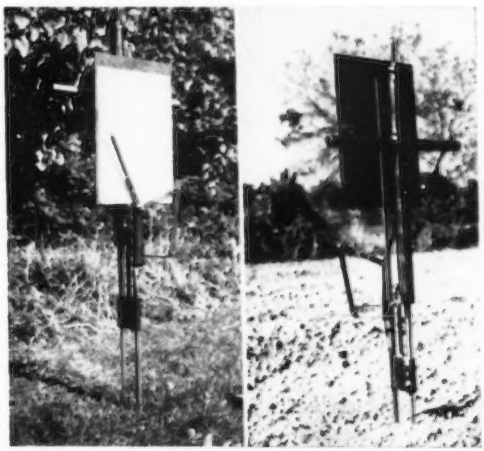

Fig. 2. An easily constructed soil penetrometer setup ready for soil testing.

Conditioning Grain for Storage

(Continued from page 424)

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Wood Trussed Rafters

By Paul W. Stoneburner and E. George Stern
ASSOC. MEMBER ASAE

A SELF-SUPPORTING roof to provide a support-free interior is useful and essential in many structures. Houses, dairy barns, cattle-feeding barns, machinery sheds, poultry houses, community buildings, livestock sales pavilions, and pasteurizing plants are a few examples of rural structures where this type of roof construction is desirable.

Wood trussed rafters are a means of providing a self-supporting roof that is especially suitable for rural construction. They are usually spaced to four feet apart whereas roof trusses are spaced ten or more feet apart. Trussed rafters are therefore lighter in weight and easier to erect than roof trusses. They can be made of the most common timber sizes. One-inch-thick sheathing boards can be used as a roof deck which is common practice in conventional roof construction. In addition, trussed rafters provide support for ceilings and eaves without additional framing.

This paper was presented at a meeting of the Virginia Section of the American Society of Agricultural Engineers at Natural Bridge, Va., April, 1952. It reports results of a study currently being undertaken at the Virginia Polytechnic Institute under the combined auspices of the agricultural and engineering experiment stations. A detailed report of the results of the study will be available within a few months.

The authors: PAUL W. STONEBURNER, assistant agricultural engineer, agricultural experiment station, and E. GEORGE STERN, research professor of wood construction, engineering experiment station, Virginia Polytechnic Institute, Blacksburg.

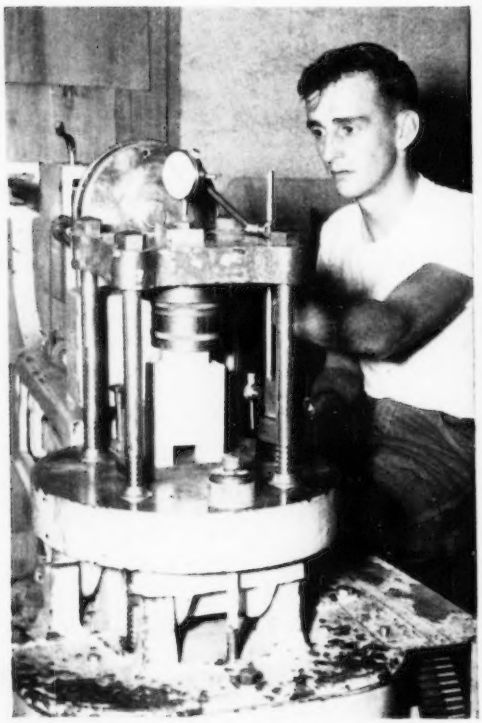
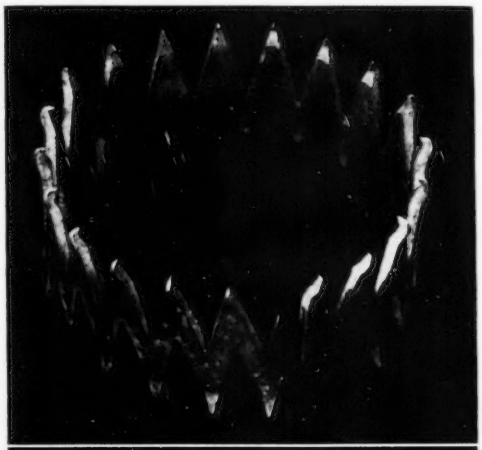


Fig. 1. Test setup for determination of load-carrying capacity of three-member joints.

Several methods of joint connection can be used: (1) bolts,



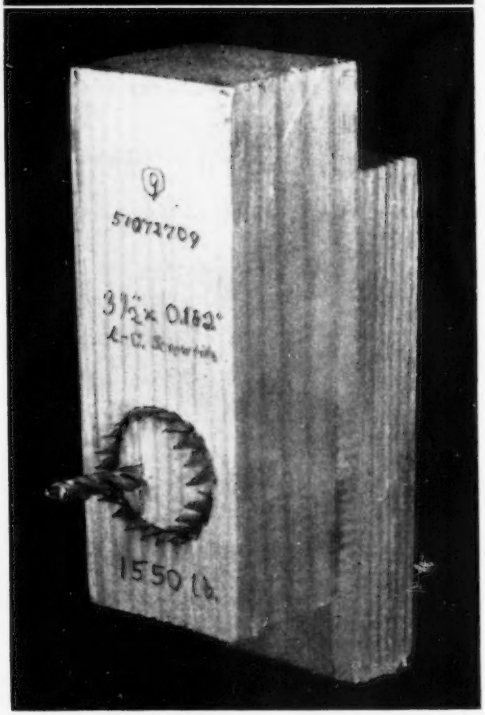


Fig. 2. (Above) Toothed-ring Buttlock fastener of 1-in. diameter. • Fig. 3. Three-member joint nailed with 3½-in. long helically-threaded Screwtite nail and 1-in.-diameter toothed-ring Buttlock fasteners, with one side member removed after completion of test.

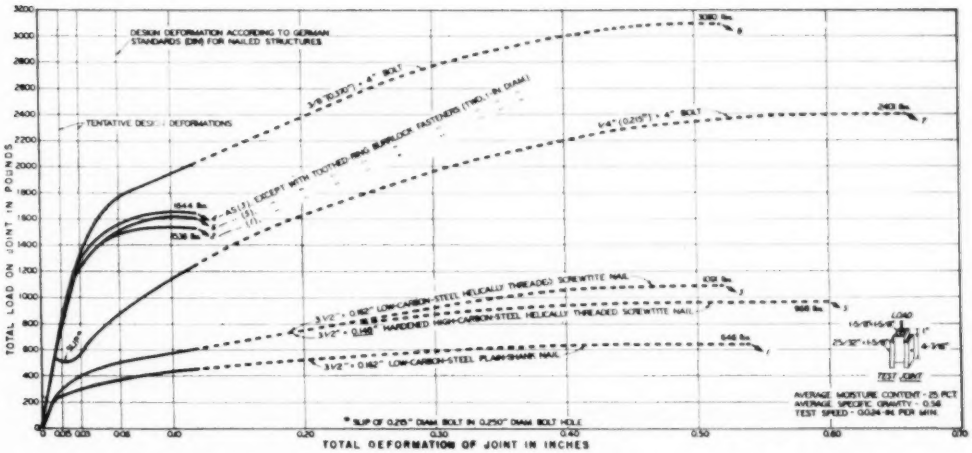

DESIGN DEFORMATION ACCORDING TO GERMAN STANDARDS (DIN) FOR NAILED STRUCTURES
TENTATIVE DESIGN DEFORMATIONS
3/8" (0.372") × 4" BOLT
1/4" (0.250") × 4" BOLT
AS (1) EXCEPT WITH TOOTHED RING BURRLOCK FASTENERS (TWO IN DIAM)
3 1/2" - 0.162" LOW-CARBON-STEEL HELICALLY THREADED SCREWTITE NAIL
3 1/2" - 0.148" HARDENED HIGH-CARBON-STEEL HELICALLY THREADED SCREWTITE NAIL
3 1/2" - 0.162" LOW-CARBON-STEEL PLAIN-SHANK NAIL
3080 lbs.
2463 lbs.
1544 lbs.
1536 lbs.
1092 lbs.
966 lbs.
646 lbs.
LOAD
TEST JOINT
AVERAGE MOISTURE CONTENT - 25 PCT
AVERAGE SPECIFIC GRAVITY - 0.58
TEST SPEED - 0.024 IN PER MIN.
* SLIP OF 0.270" DIAM BOLT IN 0.250" DIAM BOLT HOLE
TOTAL LOAD ON JOINT - IN POUNDS
TOTAL DEFORMATION OF JOINT IN INCHES

Fig. 4. Average load-deformation curves for three-member green southern pine joints in compression parallel to grain according to matched quadruple tests immediately after assembly.

(2) timber connectors, (3) nails, and (4) a recently developed miniature toothed-ring connector.

Bolted Joints. Trussed rafters assembled with bolted joints are relatively limber and deflect considerably under load. Large joint areas are necessary for installation of bolts because of the large end distance required; consequently, relatively large-size lumber is needed. Considerable time and effort is required to drill holes for the bolts. These factors limit the effectiveness of bolted joints in trussed-rafter design.

Connectored Joints. Timber connectors provide more rigid joints than bolts and thus make it possible to erect large-span, heavy-duty timber structures. Their development made feasible the use of timber structures in many instances where they had been previously impractical or impossible. There are several types of timber connectors, but the 2½-in-diameter, split-ring connector is most commonly used in trussed-rafter construction. However, several disadvantages limit their use. An expensive grooving tool must be available. Although grooving and assembly are not too difficult, the construction is better suited to assembly-line production than to rural field condi-

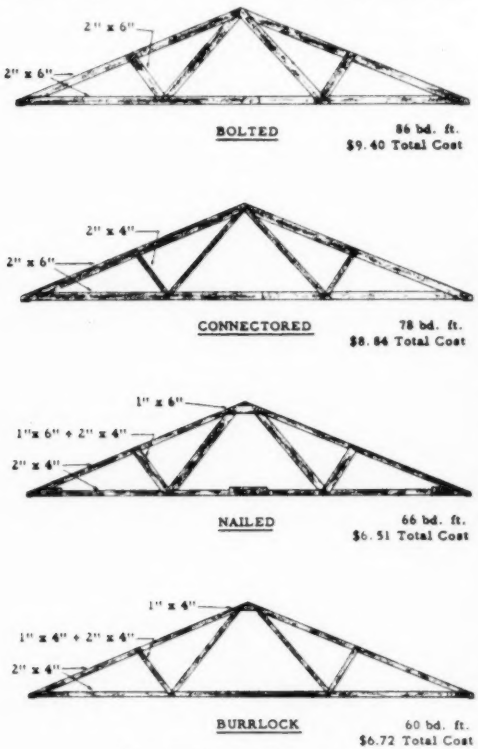


Fig. 5. Wood trussed rafters, 26-ft span.

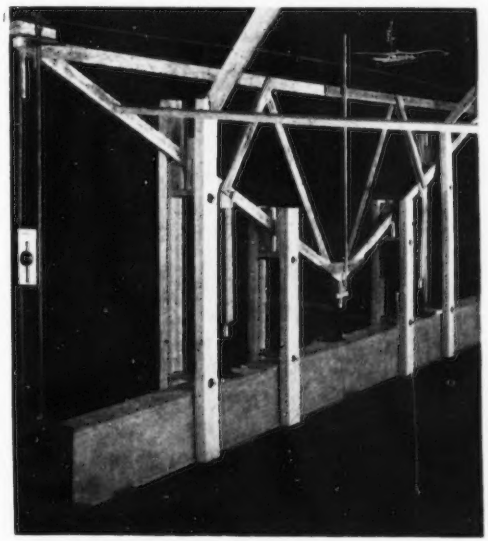


Fig. 6. Burrlock trussed rafter under test observation.

tions. Furthermore, the number of sales outlets for the connectors and tools is limited.

Nailed Joints. Nails are relatively low in cost and are readily available. Only a hammer is required for making a nailed joint, and joint strength can be varied in small increments by the addition or deletion of one or more nails. Although nails should not be used for repetitively, dynamically loaded structures such as highway bridges, they are well suited to jointing trussed rafters. Design data for nails are few, and no data have been available for nails joining three members simultaneously, as may be desirable in trussed-rafter joints. To develop such design data for nails in lateral loading, a relatively large number of nails in two-member and three-member compression joints was recently tested at Virginia Polytechnic Institute. The results show that low carbon-steel, plain shank (common nails) and threaded-shank nails in the tested green southern pine joints (Fig. 1) carry twice as much load when joining three members as when joining two members. However, this is valid only if the nail diameter is not too large for the thickness of the joint.

Buttlock Joints. Relatively low-cost miniature toothed-ring Buttlock connectors (a product of Metal Industries, Inc., Youngstown, Ohio) of 1 in. diameter (Fig. 2) have recently been introduced as lumber fasteners which can be used for nailed structures and assemblies. They provide rigid joints with a minimum of joint area required.

A Buttlock-reinforced, three-member joint with one side member removed after testing is shown in Fig. 3. Design data for Buttlock-reinforced nailed joints are graphically presented in Fig. 4. It can be seen from these tests that, if combined with nails, the Buttlock fasteners can replace small diameter bolts. Furthermore, tests on trussed rafters show that under certain conditions they can also replace both large-diameter bolts and split rings. Trussed rafters can be built with a minimum of lumber and hardware, although joint assembly may be difficult and time consuming.

TESTS ON TRUSSED RAFTERS

Wood trussed rafters, as shown in Fig. 5, were assembled at Virginia Polytechnic Institute with the four previously described jointing methods. They were tested, as shown in Fig. 6, by inverting them and applying equal loads at the center and the two panel points by means of three hydraulic rams. For a given design load, all the trussed rafters deflected less than allowable and provided ample ultimate load-carrying capacity. Therefore, they can be classed as structurally satisfactory. Materials required to build them are as follows:

Method of joint assembly	Lumber required in fbm	Cost of lumber and hardware
Connectored	78 (100%)	$8.84 (100%)
Bolted	86 (110%)	$9.40 (106%)
Nailed	66 (85%)	$6.51 (74%)
Buttlock	60 (77%)	$6.72 (76%)

Thus the materials used for the construction of nailed and Buttlock assembled trussed rafters, fulfilling the same requirements, cost about one-fourth less than those required for bolted and connectored assemblies.

Nailed trussed rafters are especially suitable for rural construction. They can fulfill a definite need in the construction of an economical and easily assembled clear-span roof structure.

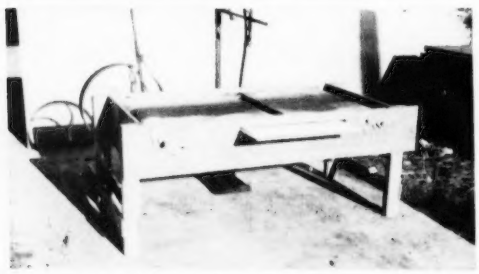


Fig. 1. A reconstruction of the Riley sprayograph.

The Riley Sprayograph

By G. L. Shanks and J. J. Paterson
MEMBER ASAE MEMBER ASAE

VARIOUS proposals (1, 3)* have appeared recently in AGRICULTURAL ENGINEERING for study and testing of spray nozzles. These test apparatuses are particularly suited to testing low-volume herbicide spray nozzles as to their mode and rate of application. It is probably known to few that in 1909 Howard W. Riley, a charter member of ASAE (2), devised a simple and in our opinion most effective test apparatus. We have recently reconstructed this apparatus in a somewhat simpler form and find it especially valuable in determining the characteristics of solid and hollow cone-type nozzles. It is of course equally suited to fan-type nozzles.

The reconstructed apparatus is shown in Fig. 1. It may be described as a framework 6 x 3 ft supporting two 6-in. rollers on which run a canvas belt. The whole apparatus is thus very similar to the table canvas assembly of a grain binder. The canvas is spliced so as to leave a slit about 3/4 in. wide between its ends. A shallow drawer centrally placed between the upper and lower surfaces of the canvas carries a sheet of paper. This may be noted partially withdrawn in Fig. 1. The canvas is driven by a small motor at a speed of 200 fpm but other speeds and widths of slit may be required under special circumstances. When spray is directed downward toward the paper the moving slit acts in the same manner as the slit in a focal-plane camera shutter. Hence, if a colored spray is used, the result is in effect a snapshot of the instantaneous discharge of the nozzle. As both the nozzle and paper are stationary the droplets falling on the paper are undisturbed.

The accompanying spray patterns (Fig. 2) show some results obtained by the use of this equipment.

For studies involving abnormalities in nozzle manufacture this apparatus has many advantages.

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This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors, G. L. SHANKS and J. J. PATERSON, respectively, professor and assistant professor of agricultural engineering, University of Manitoba, Winnipeg.

*Numbers in parentheses refer to the above references.

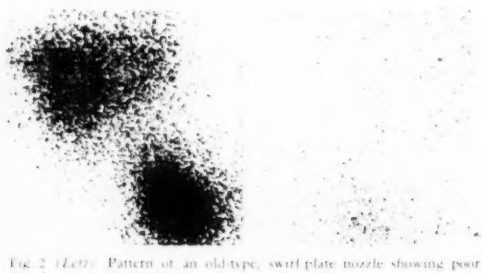

Fig. 2 *(Left)* Pattern of an old-type, swirl plate nozzle showing poor distribution. • *(Right)* Pattern of an up-to-date solid-cone-type spray nozzle.

A Forced-Ventilation Tobacco Curing System

By E. Martin Matthews and Vernon H. Baker

ASSOC. MEMBER ASAE

FOR nearly 100 years farmers in the flue-cured tobacco belt have known how to cure fine-quality tobacco, but only in recent years have they seriously considered the high cost of curing bright leaf tobacco with inefficient barns and the big waste of fuel from using open furnaces. It is estimated that the curing process costs about 20 per cent of the total cost of production. During the past 20 years much progress has been made in developing better curing systems, especially coal-stoker and oil-burning curers capable of maintaining uniform temperatures.

Experiment stations in several tobacco-growing states have contributed to this progress. They have not only tested many commercial curers but have also designed and tested equipment of their own. According to Moss and Teter (1)* inefficient barns and improper procedure will cause green tobacco, sponging, scalding, black stem, and perhaps green fibering. Brown (2) states that the three things which saved fuel in barns constructed at Oxford, N. C., were (a) more even temperature throughout the barn; (b) better heat insulation, and (c) better control of the air flow through the tobacco. With the idea of developing a system that would lower the cost of curing and improve the quality of the leaf, a forced ventilation system was built and tested.

Description and Operation of System. A sketch of the forced ventilation curing system installed in a 16½ x 16½-ft barn is shown in Fig. 1. The barn is of frame construction, weather boarded on the outside and lined on the inside with ½-in gypsum board.

A centrifugal fan driven by a ½-hp electric motor blows about 10 cfm of air per square foot at ½ in static pressure, into the heating jacket. As long as the humidity between the tobacco leaves is at the proper level for curing (Fig. 2), the recirculation system will operate and the air will be moved through the metering orifices, distributed along the heating jacket, up through the tobacco and then down through the recirculation duct. Whenever the moisture in the air moving through the tobacco exceeds the setting on the humidity control, the damper motor will be energized which will in turn open the upper and lower ventilators (3). This allows fresh air to be drawn in at the bottom ventilator and moist air to be blown out at the top ventilator. After moist air is exhausted the ventilators will close and recirculation will continue.

Summary and Results. Use of this system for four seasons has shown the possibility of lowering fuel and labor costs in curing bright tobacco. The main advantages of this system over other systems (including regular coal-fired furnaces, oil curers, and wood-fired furnaces) are as follows: Forced ventilation and recirculation by a fan made it possible to lower the high temperatures usually required in the final stages of curing, without prolonging the curing time. This lessened the fire hazard. With this system the barn temperature may be lowered rapidly after the tobacco is dry. This system made possible successful cures when the barn was loaded from 140 to 150 per cent normal capacity by stacking the sticks much closer on the tiers, without damage from sponging or scalding. This extra leaf was cured without any appreciable increase in fuel. The quality of leaf from this system was as good as that

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors: E. MARTIN MATTHEWS, associate agronomist and superintendent, Bright Leaf Tobacco Station, Chatham, Va.; VERNON H. BAKER, associate agricultural engineer, Virginia Agricultural Experiment Station, Blacksburg.

AUTHORS' NOTE: The authors wish to acknowledge the contributions of G. E. Barlow, Jr., assistant agricultural engineer, and R. B. Davis, Jr., associate agricultural engineer, Virginia Agricultural Experiment Station, before their resignations in December, 1948, and March, 1950, respectively.

*Numbers in parentheses refer to the appended references.

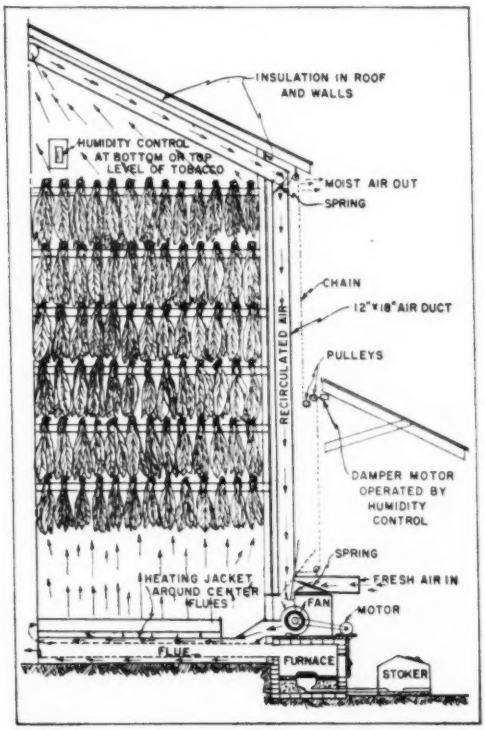

Fig. 1 Cross section of experimental forced-ventilation curing barn

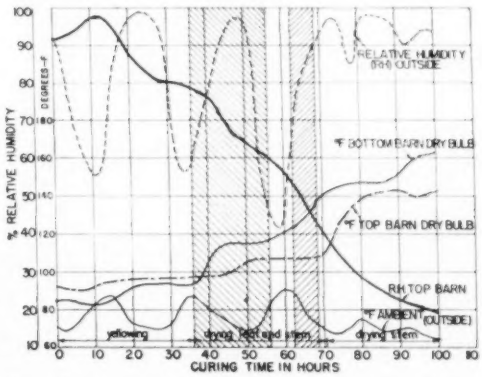

Fig. 2 Temperature and relative humidity for one curing in the forced ventilation barn, showing the time for yellowing the leaf, drying leaf and stem, and drying stem. The ventilation system is not operated during the yellowing period. The crosshatched area shows the time the circulating system cycled to bring in fresh air. From 68 to 100 hr curing time, the recirculating system was in constant operation

Drainage Practices and Problems in Puerto Rico

By M. Lugo Lopez and M. B. Martinez

POPULATION pressure upon the limited resources of Puerto Rico necessitates the growing use of intensive cultivation methods, soil conservation, and reclamation in order to increase the agricultural output to meet ever-increasing demands. The mean annual rainfall ranges from less than 25 in in the southwestern part of the Island to more than 200 in at the Luquillo mountains in the northeast. It averages about 60 in along the north coast, 35 in in the south coast, and around 100 in in the mountainous interior.

The soils are surprisingly variable for such a small territory. More than 550 soil types have been grouped into 115 series. The deep soils of the uplands are generally well drained, but there are often seepage spots in the medium-deep and shallow soils where slowly permeable rock layers force percolating water to the surface. Moreover, the large runoff which must be disposed of in the tropics often calls for drainage ditches and other suitable measures in the uplands to save both crops and soils. There are also about 37,100 acres of saline soils which are at present mostly idle or in native pastures of very low carrying capacity. Drainage plays an essential part in the improvement of salty soils. Furthermore, there are over 58,000 acres of poorly drained soils, about half of which are organic, most of which could be reclaimed for agricultural purposes by proper drainage through the installation of major engineering works.

Open ditches are used generally for removing excess water in cultivated fields. If well constructed, they usually have ample capacity and can dispose of the water quickly at a low grade. On the other hand, they can waste as much as 10 or 15 per cent of the area, and they demand a yearly upkeep expenditure. Sometimes, if not well constructed, they are ineffective, inconvenient, and may encourage erosion.

The drainage pattern in a typical imperfectly or poorly drained mineral soil devoted to sugar-cane cultivation would be more or less as follows: Small ditches 6 to 12 in wide by 6 to 12 in deep every 8 or 12 ft, i.e., every two or three rows of cane. These ditches will drain into larger cross ditches 12 to 16 ft apart which in turn will discharge their waters into master ditches 2 to 4 ft deep which follow the topography of the land.

In tobacco plantations, which are usually on fields with slopes of more than 10 per cent, shallow ditches are dug around every plot (each plot encloses about 900 to 1,200 sq ft) giving the field the appearance of a gridiron. In that way the water travels only short distances before entering the ditches and therefore loses its erosive power.

In coffee plantations holes or pits 1 ft by 1 ft and about 8 to 12 in deep are dug near most of the coffee trees. During rains these holes catch runoff water and sediment, and check the speed of the water.

Under present conditions the establishment of ditches in the lowlands ranges anywhere between $40 and $60 per acre. Afterwards their maintenance costs are much lower, ranging from $5 to $12 per acre. In the uplands devoted to sugar cane, the establishment of drainage ditches may run as high as $25 or $50 per acre, with subsequent maintenance costs of some $4 or $6 annually. The digging of holes and other drainage and moisture-conservation practices in the coffee areas may cost anywhere from $7 to $12. Every two or three years the holes get full of sediment and must be cleaned.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors, M. A. LUGO LOPEZ and M. B. MARTINEZ, respectively, associate soil scientist and research assistant in agricultural engineering, Puerto Rico Agricultural Experiment Station, Rio Piedras.

Tobacco Curing System

(Continued from page 429)

cured with other systems. During two years when forced ventilation was used for a total of nine curings in a standard four-room barn, the average cost for fuel and electricity combined was 82¢ per 100 lb of leaf cured. This compares with $1.92 per 100 lb of leaf cured in a similar size barn operated for nine weeks the same two years with an efficient oil curer, and $1.08 per 100 lb of leaf for a coal stoker operated for 14 curings in the same barn prior to installing the forced ventilation system. (Costs based on $18.50 per ton for stoker coal, 13.1¢ per gallon of fuel oil and 1½¢ per kw-hr for electricity). The curing data in this report may be used as a guide for curing bright leaf tobacco with forced ventilation. However, there is no exact method of predicting performance data for different types of barns; the curing procedure will vary slightly with the maturity of tobacco, each priming, and atmospheric conditions. The forced-ventilation system does not eliminate the need for an experienced tobacco curer during the curing process.

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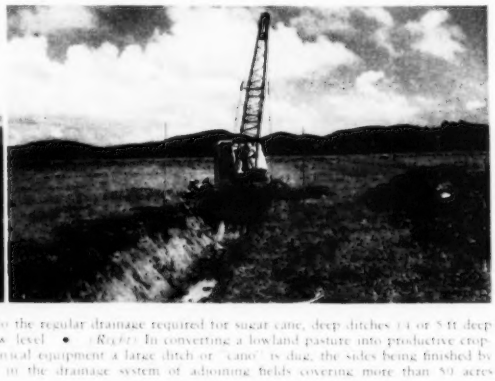


(*Left*) In a low field which is subject to frequent overflows, in addition to the regular drainage required for sugar cane, deep ditches 4 or 5 ft deep and 2 ft wide are dug at close intervals to keep the flood waters at a low level. • (*Right*) In converting a lowland pasture into productive cropland one of the first steps is to provide adequate drainage. Using mechanical equipment a large ditch or "canal" is dug, the sides being finished by means of hand shovels. This "canal" will serve as the main outlet to the drainage system of adjoining fields covering more than 50 acres

The 1952 ASAE Gold Medalists

I. D. WOOD

The American Society of Agricultural Engineers awarded the John Deere Medal to Ivan D. Wood and the Cyrus Hall McCormick Medal to Charles J. Scranton at Kansas City, Missouri on June 18

C. J. SCRANTON

IN THE selection of Ivan D. Wood to receive the John Deere Gold Medal for 1952, the Jury of Awards of the American Society of Agricultural Engineers gives recognition to a great "grass roots" teacher. And, as seems in fair way to become a tradition, it is not some single or several spectacular achievements which has earned the award, but the cumulation of a long and busy career.

Ivan Daley Wood was born October 17, 1888, at La Platte, Nebraska, starting a life which might well earn him an award as a great Nebraskan. His education commenced in the common schools of La Platte and Fort Crook, continued at the Belleview (Nebraska) Academy, and culminated at the University of Nebraska where in 1912 he received his bachelor of science degree in agricultural engineering — one of the first in the United States to be graduated with this degree. A year later he received the master's degree.

His work in the summer of that year, 1913, was prophetic. As instrument man and engineer for the John L. Roper Lumber Company in North Carolina, his survey of the Pungo River Drainage Project pointed toward his later work with structures and with soil and water. That fall he returned to the University of Nebraska as instructor in those subjects, but he was captive of the campus for only one academic year.

In 1914 he became extension engineer of the state agricultural extension service — something new in Nebraska and almost new anywhere. Besides the prior subjects his work included farm machinery, and the objective was to "carry the work of the Experiment Station to the farms of the State by means of practical demonstrations on privately owned land and by schools of instruction. The methods developed were adopted by many states."

During 1918-19 Mr. Wood took time out to serve with the Aviation Section, Signal Corps, U.S. Army. Besides training he had a modicum of flying hours and a major assignment in charge of the machine and motor repair shops at Gerstner Flying Field, Lake Charles, Louisiana.

From early 1919 to October of 1940 he was State Extension Agent in agricultural engineering, yet this work was but the trunk from which grew many branches. In 1934-35 he was State Emergency Conservation Work Director, supervising the organization of seventeen U.S. Forest Service erosion control camps and instruction of their personnel. Work surveyed and supervised by these camps included extensive terracing, water conservation and soil-saving dams, and planting of 11½ million trees.

For nearly a year, in 1935-36, Mr. Wood was Chief of Engineering, Plains Shelterbelt *(Continued on next page)*

IN CHOOSING Charles J. Scranton to receive the Cyrus Hall McCormick Gold Medal for 1952, the Jury of Awards of the American Society of Agricultural Engineers has done more than honor "exceptional and meritorious achievement in the application of engineering to agriculture." It reveals to other engineers, and especially to those embarking on their careers, an inspiring example which has been too well cloaked in the mantle of modesty.

Son of Charles Jackson Scranton, Sr., and his wife, Caroline Henry, our medalist was born April 4, 1892, at Peoria, Ill. In 1912 he was graduated with diploma in the mechanical arts group from Bradley Polytechnic Institute, which then was essentially an academy and junior college. Immediately he began the forty years of work with the farm machinery industry which was to be both career and higher education.

For a short time he did detailing and drafting for the Holt Machinery Company then newly established at Peoria and now become the mighty Caterpillar Tractor Company. In the fall of that same year, 1912, he joined the Avery Company, also of Peoria, a major builder of "heavy" farm machinery under guidance of the legendary J. B. Bartholomew.

There he drafted designs for jigs, fixtures and special equipment, and spent a year in the factory as pattern maker and on the assembly line. From 1916 to 1924 he worked directly for Mr. Bartholomew, nurturing many of the numerous and often unorthodox ideas for which the latter was known, as well as routine engineering on the company's threshing machinery. In these years he worked on the sliding-frame tractor, the motor cultivator which forecast the modern all-purpose tractor, the "road-razor" which was a maintainer for the roads of the era, and the Avery header-thresher which looked toward the combines of today.

In 1924 Mr. Scranton turned to what he calls free-lance engineering, in the course of which he developed a manure spreader for the Rotary Spreader Company, Mason City, Illinois. He also designed a railroad gate for the Chas. Buttrick Company, Springfield, Illinois.

In 1925 he rejoined Avery, reorganized under the new name of Avery Power Machinery Company, and as its chief engineer was responsible for its combines as well as a line of steel threshers. In 1934, he became chief engineer at the La Porte, Indiana, plant of the Allis-Chalmers Mfg. Company, which had been taken over from the Advance-Rumely Company. He continues in this position.

Here, along with much that is routine and meritorious, he has done things that are exceptional. Among them, he directed development of the All-Crop Harvester, the first widely ac-

cepted small combine for power take-off drive, and a machine sharply unconventional in design. Another is the Roto-Baler which produces, instead of the traditional rectangular bale, a cylindrical rolled bale bound with twine. He also did pioneer work on the field forage harvester.

Despite the daring with which he has time and again departed from conventional lines of design, he is far from the "lone eagle" which his independent thinking might suggest. Rather he has a rare capacity for cooperation and leadership which has earned for him the admiration, indeed the affection, of fellow engineers, in other companies as well as his own. One of them says:

"Only those few who are very well acquainted with Mr. Scranton's work know of his outstanding record in the development of people. His effort in this direction has been so effective that, when he has developed a new machine which is to be transferred to a new plant, he has a corps of engineers ready to assume complete responsibility for the design."

Another tells of working with Mr. Scranton on the Farm Equipment Institute's advisory engineering committee from its inception in 1938, and says: "His contribution in this work has been outstanding. He is very cooperative in dealing with the problem at hand, and as a rule goes to the depths of the issue. If he is right he maintains his stand to the limit; if he's wrong he's willing to change his mind and get behind the issue and be as strong for putting it over as anyone. You admire a man like that.

"His ability to distinguish the difference between theory and common sense has been an accomplishment clearly shown in his implement designs. . . . In the farm equipment industry there has always been a need for standardization to a certain extent of certain items. Charlie is one of the first to recognize this and really get behind it to push it through. He has the ability to judge whether the issue is in the classification for standardization."

Working through technical society memberships and committee assignments therein he has played a major role in standardization programs for tractors and implements involving drawbar designs, power take-off connections, V-belt length measurements, safety measures and others which have been adopted by industry and put into everyday use. Both for talent and leadership he applied to a perplexing problem, and for its great human significance, his work on safety shielding of power take-off shafts has earned special esteem for Mr. Scranton.

His friends tell of his fondness for fishing, and his annual spring pilgrimage to Canadian lakes for its indulgence. However, it was in lazy backwater of the Illinois River that his fishing exemplified the engineering qualities of prompt decision and energetic action. The locale abounded in snakes, and when he dozed off he dreamed that one crawled up his arm. So he jumped out of the boat.

No matter how determined his departure from daily duty, his associates aver that he never ceases to be the engineer. His brain children are born in the Canadian wilds, in his garden at home, or even in church — where, it is alleged, he has been known to smuggle an old envelope from his pocket and sketch the image of an idea.

This presumably, was a church of the Universalist faith, to which he belongs. His fraternal connection is with the Benevolent and Protective Order of Elks. Besides his activity in the Farm Equipment Institute, Mr. Scranton is a member of the Society of Automotive Engineers and of the American Society of Agricultural Engineers, which latter he joined in 1927 and wherein he is now honored. His family consists of his wife, the former Elsa M. Spaninger, and their son, Robert Jackson Scranton.

It is not as a writer that Charlie Scranton is known, though he has presented technical papers at ASAE meetings. Nor does his distinction lie largely with invention, though he has taken out some thirty patents. Rather is it in the caliber of his creative talent in development of machines for industry, his constructive critical judgment of policy by and among units therein, his development of subordinates and his capacity for leadership among engineers of cooperating, albeit competing, companies.

I. D. Wood—John Deere Medalist

(Continued from page 451)

Project. This activity involved surveys of shelterbelt strips in six states, planning and irrigation of nurseries, surveys and experiments in water conservation measures. Meanwhile there developed the great drought that started in 1934, peaked in 1936, and ran into 1937.

Aided by grants from the federal Public Works Administration, Mr. Wood focussed attention of the Extension Service on alleviation of the drought by means of pump irrigation. Farmers affected were familiar only with dry-land methods, and their guidance in pumping and irrigation was achieved by hundreds of meetings and demonstrations with aggregate attendance exceeding 40,000.

During all these digressions and duality of duty, Mr. Wood held to his anchorage in the State and the University of Nebraska. It was in October of 1940 that he shifted his base to Denver, Colorado, and his full affiliation to the U.S. Department of Agriculture. Here he has been district engineer and principal construction engineer in the Farm Security Administration, construction engineer in the Soil Conservation Service, and since May of 1946 irrigation engineer attached to SCS research.

In all these shifts, mainly in organization, and in scope which embraced sometimes seven, sometimes seventeen states, and despite a range of duty including nearly all aspects of agricultural engineering, his major and most consistent domain has been that of soil and water management. In very truth he has in gospel measure been applying art and science to the soil.

Despite his eminence in the domain of water, in both its drainage and irrigation aspects, Mr. Wood was also a trail blazer in soil erosion control. A Nebraska graduate recalls a field trip in 1920 or 1921 for study of terraces already built at Ashland, Nebraska, under guidance of Mr. Wood in the course of his grass-roots teaching. His later activities in gully control, dam building, tree planting and shelter-belt establishment reveal well-rounded orientation in the wind as well as water phases of erosion.

It was in 1919 that he became a member of the American Society of Agricultural Engineers. From that time forward he and his fuming briar pipe became a legend at the meetings of the Society. Almost as incredible as his leaving Nebraska has been his appearance in recent years without the pipe.

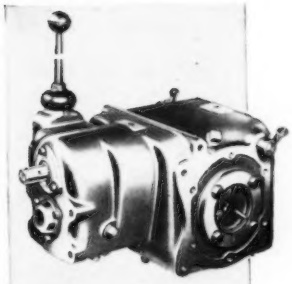
Through all the years he has taken a major part in the hard work of Society committees and divisions. Besides a whole list of assignments in the field of soil and water, he has worked on farm building design, dairy construction and equipment, cooperative building plan service, farm structures economics, paper awards and meetings committees. He has twice been chairman of what is now the Soil and Water Division, and he now becomes president of the Society for 1952-53.

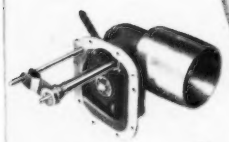
Mr. Wood's writing, like his teaching, has been at the grass roots. It shows 118 titles appearing in farm journals, building trade papers, and general publications. Likewise he appears as sole or joint author of 31 bulletins and circulars of the University of Nebraska, most of them marked "Extension."

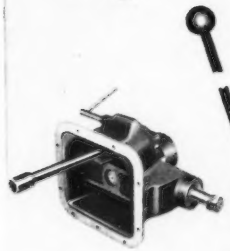
Associates of Mr. Wood pay tribute not only to his talent as an engineer, his capacity as an administrator and his genius as a teacher in the field, but to his art as an amateur photographer. His neighbors know him for versatility in handicrafts and skill in mechanics.

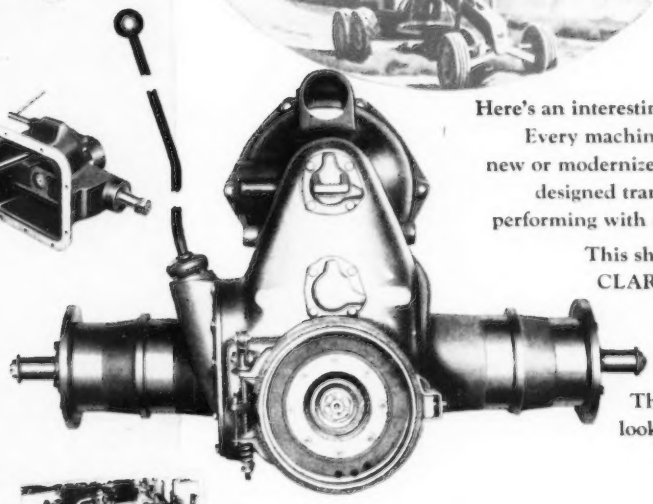
His major avocation, shared with Mrs. Wood, is the study of North American archaeology, particularly in the Southwest. Their current vacation project is a pilgrimage to the Mayan ruins of Chichen Itza, Uxmal and others in Yucatan and Guatemala. Mrs. Wood is the former Dorothy C. Good. The family includes son Eugene Donaldson and daughter Barbara Louise.

Mr. Wood is member of the professional fraternities Sigma Tau, Alpha Zeta, and Gamma Sigma Delta. Other affiliations include the Farm House Fraternity, Lincoln University Club, and Presbyterian Church. He is a member-at-large of the National Council, Boy Scouts of America.









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NEWS SECTION

ASAE Program for Centennial of Engineering Convocation

A SPECIAL agricultural engineering program is being arranged by the American Society of Agricultural Engineers in connection with the Centennial of Engineering Convocation to be held at Chicago, September 5 to 15, 1952.

The ASAE program will be presented Monday and Tuesday, September 8 and 9, at the LaSalle Hotel in Chicago. The four technical divisions of the Society — Power and Machinery, Rural Electric, Farm Structures, and Soil and Water — have each accepted responsibility for the program of a one-half day session, and in addition a special dinner program is being arranged for the evening of Monday, September 8. Details of the program follow:

The meeting will open at 9:00 a.m., Monday, September 8, with a Farm Structures program, at which David B. Poor, chairman, Farm Structures Division, ASAE, and agricultural engineer, Stran-Steel Division, Great Lakes Steel Corp., will preside. Three speakers are featured on this program. William G. Kaiser, agricultural engineer and assistant director of promotion, Portland Cement Association, will review a century of progress in farm housing and storage structures. The subject of current research and developments in farm structures will be discussed by Wallace Ashby, head, farm building and rural housing division, U.S. Department of Agriculture. The third speaker will be Deane G. Carter, professor of farm structures, University of Illinois, who will present the challenges awaiting agricultural engineers in the field of farm structures.

The Power and Machinery program will be presented at 2:00 p.m. on the afternoon of September 8, with R. L. Worrell presiding. Mr. Worrell is chairman of the Power and Machinery Division and project engineer, tractor division, Allis-Chalmers Mfg. Co. This program will open with a talk on the evolution of farm implements during the past 100 years by Eugene G. McKibben, director of agricultural engineering research, U.S. Department of Agriculture. Harry B. Walker, professor of agricultural engineering, University of California, will then present an engineering appraisal of the economic and social results of farm mechanization. The third and last speaker on this program will be K. W. Anderson, manager, product research, Deere and Company, who will talk on new horizons in farm machinery development.

A special ASAE dinner is being arranged for the evening of Monday, September 8, in the ballroom on the 17th floor of the LaSalle Hotel, in commemoration of the 100th anniversary of the organization of the first association of engineers in this country. Presiding as master of ceremonies at this dinner will be Stanley Madill, junior past-president of ASAE, and executive engineer, John Deere-Waterloo Tractor Works of Deere Mfg. Co. The speaker for the occasion will be Ivan D. Wood, president of ASAE, and irrigation engineer, Soil Conservation Service, USDA. The subject of his address will be "The Engineering Revolution in Agriculture."

The forenoon program of the second day, September 9, is to be devoted to the general subject of the soil and water phases of agricultural engineering, and the presiding chairman of the session will be G. E. Ryerson, chairman, Soil and Water Division, ASAE, and farm machinery research specialist, Soil Conservation Service, USDA. Dr. Robert M. Salter, chief, Soil Conservation Service, will open the program discussing the subject of the engineer's job in developing America's agricultural capacity to produce. He will be followed by Lewis A. Jones, chief, drainage and water conservation division, SCS, who will talk on drainage as a tool for increased farm production. The subject of irrigation in relation to food production will be the subject of an address by I. E. Christiansen, dean, school of engineering of technology, Utah State Agricultural College.

The final portion of the ASAE program, dealing with the rural electrification, will be presented on the afternoon of Tuesday, September 9, with A. H. Hemker, chairman, Rural Electric Division, ASAE, and manager, farm industry division, General Electric Co., presiding. The program will be opened by E. C. Easter, vice president, Alabama Power Co., who will speak on engineering problems in taking electric service to the farm. He will be followed by W. D. Hemker, agricultural engineer, Westinghouse Electric Corp., speaking on the latest developments in electric farm equipment. Progress in the drying of agricultural crops is the subject to be discussed by H. J. Barre, head, agricultural engineering department, Purdue University. W. J. Ridout, Jr., editor, "Electricity on the Farm" Magazine, will review research on uses of electricity in agriculture, and he will be followed by a discussion of applications of artificial light in agriculture by J. P. Ditchman, eliminating engineer, General Electric Co. As the last speaker on this program, H. S. Pringle, extension rural electrification specialist, extension service, USDA, will review progress in the efficient use of electricity in agriculture.

Printed copies of this program, as well as information on hotel reservations, registration for the meeting, etc., will be mailed to ASAE members in due course. Complete information on this meeting may be obtained from the ASAE headquarters office at St. Joseph, Michigan.

ASAE Meetings Calendar

August 25-27 — NORTH ATLANTIC SECTION, University of Maine campus, Orono.

September 8 and 9—ASAE PROGRAM, Centennial of Engineering Convocation, LaSalle Hotel, Chicago, Ill.

October 9 and 10 — PENNSYLVANIA SECTION, Penn Wells Hotel, Wellsboro, Pa.

October 30-November 1 — PACIFIC NORTHWEST SECTION, Oregon State College, Corvallis.

December 15-17—WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

June 15 to 17 — 46TH ANNUAL MEETING, Hotel William Penn, Pittsburgh, Pa.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Michigan.

Agricultural Engineers Mark Progress at Kansas City

AROUND 600 agricultural engineers, members of their families and guests assembled at Kansas City, Mo., June 15-19, for the 45th Annual Meeting of the American Society of Agricultural Engineers. The event reflected a year of progress and orientation for work on technical and professional problems immediately ahead.

As usual a large proportion of those who attend regularly showed up early to make the most of the occasion. Entertainment provided for them on Sunday evening included a complimentary buffet supper and, as a special attraction, an illustrated talk on his recent vacation trip to Guatemala and Yucatan by Ivan D. Wood.

An attendance of more than 300 at this affair was larger than expected and soon exhausted the food supply provided. With an explanation by Paul Doll, chairman of the local arrangements committee, the crowd good-naturedly accepted a delay and extension of the visiting time while the hotel prepared additional sandwiches and coffee.

C. W. Smith, chairman of the Mid-Central Section, official host group for the meeting, extended a welcome on behalf of the Section.

Technical division sessions opened Monday morning but the whole group came together for the first general session Monday afternoon.

Paul N. Doll, chairman of the Committee on Arrangements, called the session to order. Lloyd W. Hurlbut, chairman of the Meetings Committee, supplemented the welcoming remarks of others and outlined provisions for the pleasure and satisfaction of those present for the remainder of the meeting. He then called on Stanley Madill to make the president's annual address.

In his address Mr. Madill noted particularly progress as shown by activities of the various sections of the Society; by broadening contacts and interest in working with agricultural engineers as shown by leaders in related fields; by sustained and increasing demand for the services of agricultural engineers, and by a number of other yardsticks.

At the conclusion of his address Mr. Madill introduced the next speaker, Henry Dreyfuss, industrial designer, who presented an illustrated address on "The Silent Partner of the Engineer." His explanation of the manner in which the industrial designer works with engineers to improve products from the standpoint of performance, appearance, and economy, commanded the complete interest and attention of the audience.

Following the general session the annual business meeting of the Society convened at 4:00 p.m. Reports reflected progress in several specific professional and technical matters and in administration of the Society.

Monday evening was devoted to concurrent special programs and round tables.

The College Division gave its time to matters of professional outlook and training requirements and attracted the attendance of an unusual number of representatives of industry.

A separate program for extension engineers dealt with problems of extension work in industry as well as in public service.

(Continued on page 436)

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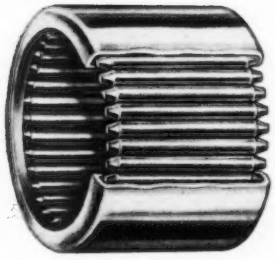

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NEWS SECTION (Continued from page 434)

The Committee on Instrumentation and Controls further explored its field and problems of spreading information on new developments and uses, both in research and in farming operations.

The Committee on Agricultural Processing reviewed its field with particular reference to current demand, opportunities and the attention being given to processing by agricultural engineers in the colleges and other public service agencies.

A popular break in the heavier fare of the meeting was the sightseeing tour, Unity Farm inspection, and chuck wagon dinner Tuesday afternoon and evening.

Wednesday afternoon's general session arranged by the College Division emphasized relations between the colleges, agriculture, and industry, particularly as to research and the training and use of agricultural engineers.

Technical division programs developed substantially as scheduled. Interest indicated that the subject matter and speakers were well chosen and offered information directly related to problems the men of these division are encountering in their work.

The exhibits arranged by the Committee on Extension occupied the entrance to the Little Theater in the auditorium. They displayed a variety of informational material and means for its effective presentation.

In their separate sessions ASAE student branch members were greeted by C. I. Zink, chairman of the committee on Student Branches. R. R. Roth, chairman of the Committee for the F.E.I. Award, announced the winning of that honor by the Purdue Student Branch for the second consecutive year.

Officers of the National Council of ASAE Student Branches, including Richard P. Walker, president; Robert E. Langford, vice president; and Robert H. Tweedy, vice-president, presided in turn at the several student sessions. Dale D. Reed, secretary of the Council, called the roll of branches and recorded minutes of the meetings.

Business taken up by the students included discussion of entries in the 1952 FEI Award competition, reports of Student Branches, plans for the 1953 National Student Magazine, and election of officers for the Council for 1952-53.

The student's program also included talks by Stanley Madill, president of ASAE; Ivan D. Wood, president-elect; Charles E. Ball, associate editor of "Farm and Ranch"; E. L. Barger, manager of farm practice research, Harry Ferguson, Inc.; and Frank B. Lanham, assistant secretary, ASAE.

As usual, one of the high points of the student's affairs was the complimentary dinner for students and faculty advisers provided through the courtesy of the International Harvester Company.

In addition to sharing with the men the several entertainment features of the meeting, the ladies present enjoyed a get-acquainted luncheon, a tour through the Nelly Don Garment Co., a tour to the Kansas City Museum and Planetarium, a luncheon at Macy's Department Store, and a tour of Nelson Art Gallery.

Wednesday evening's ASAE Annual Dinner brought the meeting to its climax and close. Ceremonies of the occasion included presentation of the Cyrus Hall McCormick Medal to Charles J. Scranton, the John Deere Medal to Ivan D. Wood, and the FEI Award to the Purdue Student Branch. Winners of the Journal Paper Awards, Student Paper Awards and Student Honor Awards were also announced.

Tom Collins, humorist and philosopher, gave the address of the evening. Speaking as "one who responds to the call of the dinner bell," he showed a keen appreciation of the work being done by agricultural engineers, and encouraged his audience to carry that work forward as something which will endure "because it makes sense."

Retiring President Stanley Madill turned the president's gavel over to Ivan D. Wood in the closing ceremonies, and Mr. Wood in his first official act as the new president of the Society presented Mr. Madill with a "past president" emblem.

Dancing followed the dinner and ceremonies.

D. O. H. Miller New Chairman of Iowa-Illinois Section

D. O. H. MILLER, project engineer, French & Hecht Division of Kelsey Hayes Wheel Co., Davenport, Iowa, was elected chairman of the Iowa-Illinois Section of the American Society of Agricultural Engineers at the Section's annual meeting held at the Short Hills Country Club in East Moline, Ill., on April 25. He succeeded W. L. Dennistion, experimental design engineer, John Deere Harvester Works, East Moline.

At the same meeting two new vice-chairmen were also elected; they are C. K. Beeman, engineering department, J. I. Case Company, Burlington, Iowa, and C. S. Morrison, chief engineer, product development department, Deere & Company, Moline, Ill.

Marlin E. Weakly, layout draftsman, engineering department, East Moline Works, International Harvester Co., was elected the new secretary-treasurer of the Section, succeeding C. R. Recor, district engineer, The Torrington Co.

The new nominating committee of the Section includes D. C. Heitshu (chairman), John Deere Harvester Works, H. S. Seeber, East Moline Works, International Harvester Co., and R. K. McConkey, The Timken Roller Bearing Co.

The technical program for the meeting included papers by J. R. Carlson, general sales manager, Berry Division, Oliver Iron & Steel Corporation, on the Berry principle of the generation and utilization of electric power; on rubber tires for farm machinery, by C. I. Zink, product research department, Deere & Co.; and kinematics of tractor hitches, by D. C. Heitshu, chief engineer, John Deere Harvester Works.

W. L. Dennistion, retiring chairman of the Section, presided at Section dinner, at which Stanley Madill, President of ASAE, and executive engineer of John Deere Waterloo Tractor Works, was the speaker of the evening.

Organization Meeting of Rocky Mountain Section

THE organization meeting of the Rocky Mountain Section of the American Society of Agricultural Engineers was held on the campus of Utah State Agricultural College at Logan on May 15, 16, and 17. More than 50 members and friends of ASAE attended the meeting and took part in the program of papers that was presented, in addition to the business of organizing the Section.

At the business session, Guy E. Woodward, extension irrigation specialist, University of Wyoming, was elected the first chairman of the Section. George D. Clyde, chief, Division of Irrigation, U.S. Soil Conservation Service, was elected vice-chairman, and Spencer H. Daines, head, agricultural engineering department, USAC, was elected the secretary of the new Section.

The group present at the meeting voted to invite the parent Society to hold its 1954 annual meeting at Logan.

Noble Elected Chairman of ASAE Washington Section

W. R. NOBLE, Washington manager, National Retail Farm Equipment Association, was elected chairman of the Washington (D.C.) Section of the American Society of Agricultural Engineers at the "Family Day" meeting of the Section held at the USDA Agricultural Research Center, Beltsville, Maryland, on June 12. He succeeds B. C. Reynolds, agricultural engineer, Office of Experiment Stations, USDA.

The new vice-chairman of the Section elected at the meeting is G. E. Ryerson, farm machinery research specialist, Soil Conservation Service, USDA.

The new secretary of the Section is Karl H. Norris, agricultural engineer, farm electrification division, USDA.

The meeting was held in the Center Building at the Research Center, and a short business session was followed by the showing of the motion picture film on the step-saving U kitchen presented by Mrs. Lenore Thye. This was followed by an hour tour of laboratories in the building. The subject of experimental farm houses was presented in the form of colored slides, with J. Robert Dodge covering the construction features and Mrs. Lenore Thye discussing functional design. Following a visit to these experimental houses, the group enjoyed a picnic supper at the residence of C. A. Logan, superintendent of the Agricultural Research Center.

Alabama Section Spring Meeting

THE Alabama Section of the American Society of Agricultural Engineers held its spring meeting at Gulf Shores, Ala., on May 16 and 17. Sixty-one members and guests, including six senior students, were present.

Topics discussed during the meeting were "Economics of Machinery for Small Farms," by Julian Brown, state director FHA, Montgomery; "New Concept of Water Disposal" by L. D. Worley, zone conservationist, SCS, Spartanburg, S. C.; "The Use of Wood in Farm Structures" by W. H. O'Brien, trade promotion manager, Southern Pine Association, New Orleans (paper presented by Mr. Frazier); "Harvesting Special Crops in Alabama" by Tom Cruvinberry, Dearborn Motors Corp., Birmingham, Mich.; "The Use of Multiple-Unit and Pipeline Milkers" by W. H. Green, International Harvester Co., Nashville, Tenn., and a 20-minute movie by the Monsanto Chemical Co., describing "Krilium". Guest speaker for the banquet was Mr. Joe D. Baldridge, John Deere Plow Co., Nashville, Tenn., who delivered an interesting address on Americanism, which was generously sprinkled with tales of Ozark relatives and "goings-on".

During the business meeting, an invitation from persons representing Florence to hold Section's fall meeting in that city was accepted. Officers elected to serve for the coming year were Chairman, C. A. Rollo, manager, Grimes Tractor and Implement Co., Montgomery, and Secretary-Treasurer, J. L. Butt, associate agricultural engineer, Alabama Polytechnic Institute, Auburn. (Continued on page 438)

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NEWS SECTION (Continued from page 436)

North Carolina Section Holds Second Meeting

THE first meeting of the North Carolina Section of the American Society of Agricultural Engineers, after its organization meeting in February, was held May 20 in Riddick Auditorium on the North Carolina State College campus at Raleigh. Following a business session during which Section by-laws were adopted, several committees appointed, and the future of the Section discussed, the group listened to an inspiring program of papers and talks.

David S. Weaver, director of the North Carolina Agricultural Extension Service talked on agricultural engineering in today's agriculture. He was followed by J. N. Howard of the Duke Power Co. who reported on progress with infrared brooding. The subject of irrigation in North Carolina was discussed by T. V. Wilson, a member of the agricultural engineering staff of North Carolina State College. W. E. Kistler of the Aeroglide Corp. talked on commercial grain drying. The program closed with a talk by G. W. Giles, head of the agricultural engineering department of North Carolina State College, on the functioning and progress of the department.

Centennial of Engineering News

AT LEAST 15 foreign nations will officially participate in the Centennial of Engineering to be celebrated in Chicago this summer. This participation is in addition to the plans just announced by the Mutual Security Agency at Washington to bring a special mission of 200 especially chosen European engineers to the Centennial as part of a five-week inspection tour of the United States, during which they will study American production methods.

The number of American engineering societies and associations pledged to take part in the Centennial has now reached 58. They have a combined membership of almost 350,000 professional engineers covering practically every technical and scientific field. Prominent in shaping the program and other activities for these various participating groups are former president Herbert Hoover, and Charles F. Kettering, world leader in engineering research.

Largest single delegation announced so far will come from the Engineering Society of Norway. It will have 17 members. The Royal Society of Industrial Engineers, Belgium, will have an 11-man delegation, while the combined group representing Great Britain's Institution of Electrical Engineers, Institution of Civil Engineers, and Institution of Mechanical Engineers is also expected to show large proportions.

Other countries with assured representations from among their leading scientists and engineers are France, Japan, the Netherlands, Switzerland, Italy, India, Canada, Mexico, Cuba, Peru, and Uruguay.

Strenuous efforts are also being made to make possible the attendance of delegations from those Latin-American nations from which no definite commitments have yet been received.

Farm Electrification Conference October 20 and 21

PLANS have been completed for the 7th annual National Farm Electrification Conference to be held Monday and Tuesday, October 20 and 21, at the Statler Hotel, Detroit, Mich. As in the past years, the Conference again will bring together key farm electrification leaders from national farm organizations, educational institutions, U.S. Department of Agriculture, industry, and sales and merchandising organizations. Approximately 300 specialists in farm and home electrification activities are expected to attend.

The "format" of the 1952 Conference will differ radically from past programs, in that it will be divided into section as well as general meetings. Section sessions will be devoted to practical discussions of electrical applications of interest to the farm homemaker and the production worker. Each group of applications will be discussed separately, with conferees invited to attend those section sessions in which they are most interested.

The "sectionalizing" of the Conference was decided upon in an effort to provide conferees with an opportunity of getting at "grass roots" answers to specific utilization problems as they pertain to certain products — appliances in the home, electrically operated time and labor-savers on the farmstead. Specialists in each line will be present to guide the discussions and to handle formal presentations.

Nationally known farm electrification and agricultural leaders will address the general sessions, which will be held on the afternoons of the two days. Section meetings are scheduled for each morning, getting underway immediately after the formal opening of the Conference on October 20.

A number of other features have been planned for the Detroit meeting, including a complimentary "industry night" program for the evening of the first day.

For those who will be arriving in Detroit on October 19, the program committee plans an informal evening forum at which a wide range of farm electrification problems will be discussed in traditional "give and take" style.

ASAE Journal Paper Awards Announced

AMONG the annual honors and awards announced during the dinner at the annual meeting of the American Society of Agricultural Engineers at Kansas City in June were the ASAE Journal Paper Awards covering the papers judged best of all those published in AGRICULTURAL ENGINEERING during 1951.

Winning papers included "Automatic Feed Grinding and Handling," by M. W. Forth, R. W. Mowery, and L. S. Foote (November); "New Concepts in Side-Delivery Rakes," by Roy Bainer (May); "Design and Performance Characteristics of the Flywheel-Type Forage Harvester Cutterhead," by Orrin I. Berge (February); "Some New Data on Resistance of Grains to Air Flow," by Claude K. Shedd (September); and "The Effect of Circular Perforations on Flow into Subsurface Drainage Tubes," by G. O. Schwab and Don Kirkham (April and May).

Honorable mention was accorded five additional papers as follows: "Brooding Poultry with Infrared Energy," by Vernon H. Baker and James H. Bywaters (June); Land Preparation for Irrigation and Drainage," by Ivan D. Wood (November); "A New Metal for Farm Tool Components," by H. L. Geiger and H. W. Northrup (March); "Irrigation Requirements of Crops," by Harry F. Blaney (December); and "Study on Septic Tanks and Septic Tank Disposal Systems," by T. W. Bendixen and S. R. Weibel (September).

The papers were judged by a committee of six representative members of the Society. Certificates of award and credit of one year's membership dues are presented to the winners.

PERSONALS OF ASAE MEMBERS

Charles E. Ball, who for several years has held the position of agricultural engineer and associate editor of "Farm and Ranch", published at Nashville, Tenn., was recently made vice-president of the publishing company and managing editor of the publication.

Sherwood S. DeForest recently became associated with the Meredith Publishing Co. at Des Moines, Iowa, as assistant editor of "Successful Farming." He was formerly extension agricultural engineer in farm structures at Iowa State College.

D. K. Fuhriman was awarded the Ph.D. degree in civil engineering at the University of Wisconsin in February and afterward joined the school of engineering staff as associate professor of civil engineering at Colorado A. & M. College. Recently he accepted appointment as associate professor of irrigation and drainage at Utah State Agricultural College, Logan, which becomes effective July 1.

Laurence H. Hodges has resigned his position as assistant professor of agricultural engineering at the University of Wisconsin to join the engineering department of the J. I. Case Co., effective July 15. He will be located at the Company's Rockford, Ill., works.

L. W. Gray recently retired as manager of the rural division of Georgia Power Co., and was succeeded in this position by one of his associates, *Bud S. Mote*, who was moved up from a position as agricultural agent. Mr. Gray is a veteran of 33 years service with the Company and has been a member of ASAE since 1922.

Julian M. Juantorena has resigned his position as engineer in the agricultural research department of Compania Tecnico Agricola Ind. S.A., at Matanzas, Cuba, is now employed as field superintendent of the Gomez Mena Sugar Mill, at San Nicolas, Cuba, which is one of the largest of its kind on the island. This mill grinds about 7,000 tons of sugar cane a day for about 160 days a year. The mill maintains an experiment station and an entomology laboratory to produce the Cuban fly *Lixophaga Diatraeae, Towns.*

Aldert Molenaar, professor of agricultural engineering, State College of Washington, has resigned to accept a five-year appointment to the position of irrigation and drainage officer with the FAO, with headquarters in Rome, Italy. His new duties will take him to various member nations of United Nations, outside of the Soviet bloc during the next five years, but primarily his work will be confined to Italy, Greece, Pakistan, and countries in the Mediterranean area.

Elwood F. Oliver has resigned his position as educational director of the Iowa Rural Electric Cooperative Association at Des Moines, to accept appointment as associate professor of agricultural engineering at Pennsylvania State College. His work will include teaching rural electrification and contacts with the electric power suppliers in Pennsylvania.

Archie A. Stone, who has been serving for nearly a year as chief of the Farm Machinery and Equipment Section of the Office of Price Stabilization in Washington, has resigned and will resume his former position as special representative of the executive offices of the International Harvester Company. His headquarters will be at the Washington office of the Company, 815—15th St., N.W., Washington, D. C.

DURKEE-ATWOOD V-BELT QUIZ

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A ☐ 5% B ☐ 10% C ☐ 25% D ☐ 35%

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A ☐ 100°F B ☐ 120°F C ☐ 150°F D ☐ 200°F

ANSWER: *A safe average is 150°F., but special heat-resistant belts are available for operation at higher temperatures. Maybe* you *have a design problem that involves extreme temperatures—or a "special" v-drive. Experienced Durkee-Atwood engineers are at your service to help you work it out.*

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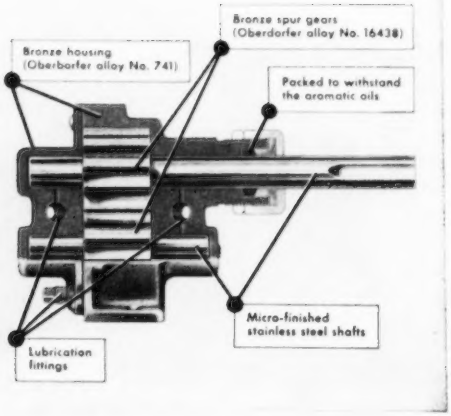

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NECROLOGY

JOSEPH WATSON GROSS, consulting civil engineer, Sacramento, Calif., passed away at his home April 26, at the age of 67. Born at Mitchell, S. D., in 1884, he received his bachelor's degree in civil engineering at the University of California in 1907.

During the next 15 years he gained a wide variety of experience with private and public employers on engineering for irrigation, city water supply, water distribution, sewage disposal, flood control and location surveys. During World War I he was assistant engineer with Monks and Johnson on work for the Emergency Fleet Corporation, with specific responsibilities in connection with water supply, fire protection, sanitation, and structures.

In 1920 he established in Sacramento the consulting practice, specializing in problems of irrigation in the Sacramento Valley, which he continued up to the time of his passing. Those years were rich with fruitful work and professional responsibility ably discharged in connection with the water supply and sanitation system for the City of Davis, sanitary districts of Galt and Elk Grove, Potter Valley Irrigation District, Sherman Island Reclamation District, Hollister Irrigation District, and the Merritt Island, Natomas District, Georgetown Divide, and Pollock Pines projects. In 1951 he had completed his work on the Mariposa Dam and water system project. Another important phase of his practice involved representing clients in engineering matters before the California Division of Water Rights, Railroad Commission, Bond Certification Commission, and others. He had also served repeatedly as expert witness in litigations concerning water rights.

His avocation was engineering history in California. In pursuing it he built up rare collections of original engineering reports, maps, plans, and profiles relating to the flood of 1862, and to the Southern Pacific Railroad.

Professionally he was a life member of ASCE, one of the organizers of its Sacramento Section, and a past-president of the Section. He had been a member of ASAE since 1927, and was also a member of the American Geophysical Union. Fraternally he was a member of the Sacramento Lodge, F & A.M., the Shrine, and Scottish Rite Body.

* * *

C. HAROLD WHITE, former member of the board of directors of Deere & Company and former general manager of the John Deere Planter Works, passed away May 9, 1952, in Greensboro, N. C.

Mr. White was born in Moline, Illinois, May 1, 1885, son of Mr. and Mrs. Charles E. White. His early education was in Moline schools. He first was employed at the John Deere Planter Works during the summers of 1904, 1905 and 1906, between terms at the University of Wisconsin, where he studied mechanical engineering and law. In 1907 he became an apprentice molder at the John Deere Planter Works, and two years later he transferred to the experimental department, where his father was superintendent.

He continued to work in the experimental department with his father until the latter's retirement in 1917, and then succeeded him as superintendent there. The following year he became plant superintendent. In 1927 he was appointed general manager of the John Deere Planter Works, and in 1928 he was elected to the board of directors of Deere & Company.

Mr. White was responsible for the development of many outstanding agricultural implements, particularly in the line of planting equipment, and including the widely known John Deere 999 checkrow corn planter. He had been granted more than 85 patents, all in the farm equipment field.

Harold White had been a member of the American Society of Agricultural Engineers since 1920, and he was the first man directly connected with the John Deere organization to be awarded the John Deere gold medal (established in 1937) by the Jury of Awards of ASAE, which honor was conferred on him in 1945.

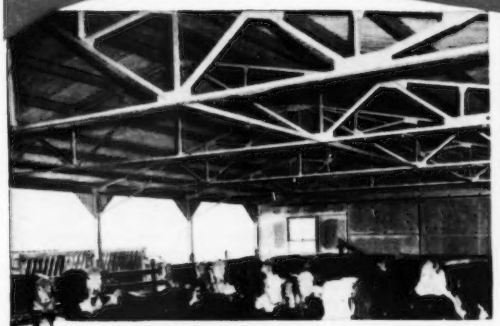
The official ASAE announcement at the time of the Deere medal award to Mr. White speaks of his "lifetime of devotion to a well-defined purpose," and gives a significant insight into his early life in this statement: "When he was eight he watched with more than a small boy's usual curiosity while his father, working in a little shop in his barn, designed a corn planter. Step by step the boy observed the shaping of patterns, the fabrication of steel parts, the fitting and assembly of parts into a complete machine. He followed it to the field for performance tests, and henceforth his life pivoted mainly around the creation and production of planting equipment."

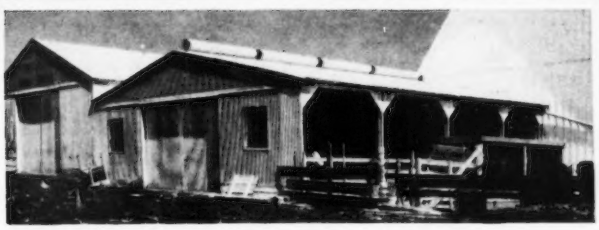
In 1949 Mr. White requested that he be relieved of major administrative responsibilities, and his resignation as general manager of the John Deere Planter Works was accordingly but regretfully accepted, although he was persuaded to join the general operating department of Deere and Company in an advisory capacity. Early in 1951 he also asked to be relieved of his duties as a director of Deere & Company, and that resignation, too, was regretfully accepted.

Mr. White is survived by the widow, the former Edna Wilson, whom he married September 25, 1912; by one daughter, Mrs. Robert Tracy of Greensboro, N. C., and by five grandchildren. Funeral services and burial were in Moline.

"After 2 fires, I'm a firm believer in steel farm buildings"

says Chris F. Hansen
Grand Mound, Iowa





Chris Hansen knows that many farmers have been wiped out by disastrous fires. Read what he has to say about this problem that concerns every farmer:

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Compare the convenience, safety and value of steel buildings against any other type of construction and you'll see why *you get more for your money when you build with steel.*

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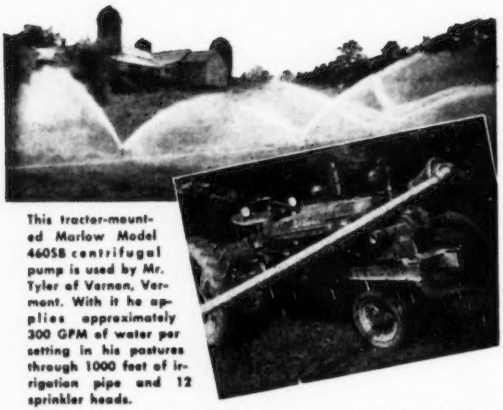
the W. C. Tyler Farm relies on MARLOW Irrigation Pumps



This tractor-mounted Marlow Model 460SB centrifugal pump is used by Mr. Tyler of Vernon, Vermont. With it he applies approximately 300 GPM of water per setting in his pastures through 1000 feet of irrigation pipe and 12 sprinkler heads.

"More than satisfied," says Mr. Tyler. "So much so I've since bought another Marlow."

MARLOWS EARNED LEADERSHIP

Farmers everywhere find that a Marlow pump is more than a seasonal investment. A Marlow can be moved readily from one location to another. In addition to sprinkler irrigation, a Marlow can be used for fertilizing, spreading insecticide, frost control, fire breaks, water supply, drainage and many other farm jobs.

Marlow centrifugal pumps are available in a wide range of models for any sprinkler irrigation job. Sizes 2 to 6 inches, including two models specifically for the new 2- and 3-acre sprinklers. Capacities 50 to 1900 GPM; pressures 30 to 200 PSI. Powered by gasoline and Diesel engines with latest safety features.

All Marlow irrigation pumps also available direct coupled to electric motors or adapted for belt drive from tractor or other auxiliary farm power unit.

Write today for complete details and name of Marlow dealer nearest you.

MARLOW PUMPS

255 GREENWOOD AVE. RIDGEWOOD, N. J.

Leading Manufacturer of Sprinkler Irrigation Pumps

TECHNICAL ABSTRACTS

EDITOR'S NOTE: Under this heading space will be made available to acceptable short abstracts of technical articles or papers of timely and conspicuous interest to agricultural engineers as published in other periodical publications, in the English or other languages.

Following are abstracts of articles on farm machinery design and air dressing (cleaning) of seed grain published in volumes 1 and 2 of the German series, titled "Grundlagen der Landtechnik," published by Prof. Dr.-Ing. W. Kloth, Volkerrode bei Braunschweig, Germany:

Measurement of the Components of Forces Acting on a Plow Body (G. Getzlaff). Measurements conducted on a plow body of steep-fronted design operating in medium-heavy loam ($v = 2.25$ mph) are used as a basis for the graphical representation of the relationship between the magnitude of the forces in the three principal directions (tractive force, vertical and lateral force), the direction of the resultant, and the magnitude of the torque about these three axes in proportion to the depth and width of furrow. A consideration of the behavior of the plow body under investigation provides a representation of the specific tractive effort required, as determined by the relation furrow width-furrow depth. The article gives several examples of the disposition of the resultant in three dimensions.

Forces Between Tractor and Implement (H. Skalweit). The article presents a graphical procedure for determining the forces occurring between implement and tractor in the various hitching systems; the plow has been selected as the example because the working resistance of this implement is known from measurement. Consideration is given to the possibility of influencing these forces in order to satisfy the demands of the farmer in respect of the quality of work performed, and to achieve beneficial effects on the pulling and steering capacity of the tractor. The article also deals with the validity of these investigations when applied to other agricultural implements, and with the need to take the present findings into account in the work of standardization.

The Kinematics of Power Lift Tools (K. Hain). The diverse demands on the transmission systems of digging tools can only be satisfied by approximation. These demands are discussed in detail and in each case several types of transmission, selected from a considerable number, are compared. The kinematic observations are based on the plow since its operative features ask for a special consideration of the respective technological requirements including, more particularly, a satisfactory depth control.

Hydraulic Jacks for Tractors (A. Seifert). Various types of power jacks — mechanical, electrical, and hydraulic — are in use with agricultural tractors; the most conventional type is the hydraulic jack. The article discusses the most important demands to be met by the industrial jack and refers to a number of German and foreign designs in order to show how many constructive features are to be applied to meet these demands. Reference is made to the principal design data in discussing the advantages and disadvantages of the various pump models. The systems adopted for controlling the raising and lowering motions are classified in accordance with new principles, and their characteristic features as well as their advantages and disadvantages are pointed out. The article concludes with a report on the results so far obtained in the investigations concerning the expenditure of work involved by hydraulic jacks used with a two-furrow plow under various operating conditions on the farm.

Rigidity of Bulky Structures (W. Bergmann). Commencing with observations on the deformation of straight, profiled bars under torsion and with a consideration of the means of preventing cross sectional bulging, the article then goes on to present the principles underlying the deformation of plane rectangular frames subjected to twisting stresses. The calculated resistance to torsion is confirmed by experiments. Reference is made to the chassis of various agricultural vehicles in describing the principles of deformation, and there is discussion of the influence of three-dimensional reinforcements and localized transitions of rigidity on the overall rigidity and durability of a bulky structure.

Stressing and Design of Spoke Wheels (H. Muller). The design and durability of an iron spoke wheel depends on the stresses imposed on the wheel body while travelling over rural tracks. For this reason the surface irregularities of roads of various classes were recorded, evaluated statistically and related to wheel diameter and width of rim. Hence, after taking the flexibility of the wheel into account, it was possible to calculate the impact energy on which the static loading capacity was based when conducting precision elongation measurements on the components of the spoke wheel. These elongation tests conducted by using a mirror extensometer revealed the influence exerted by the number, rigidity and offset of the spokes on the extent and distribution of bending stresses in the rim and spokes. Endurance tests carried out on spoke wheels on a specially constructed test stand confirmed the results of the static measurements. The fatigue cracks occurring in the spokes were near the points at which they joined the rim. *(Continued on page 444)*

what to do about old corn cribs!

they make good grain bins, with MASONITE TEMPERED PRESDWOOD

Surplus grain? Any farmer with an old, weatherbeaten corn crib or utility building can have extra storage space, easily and quickly. All it takes is Masonite ¼" Tempered Presdwood® and a little time.

This strong, smooth panel material offers a tight, dry barrier to moisture and rodents. Won't split, splinter or crack. Lasts indefinitely.

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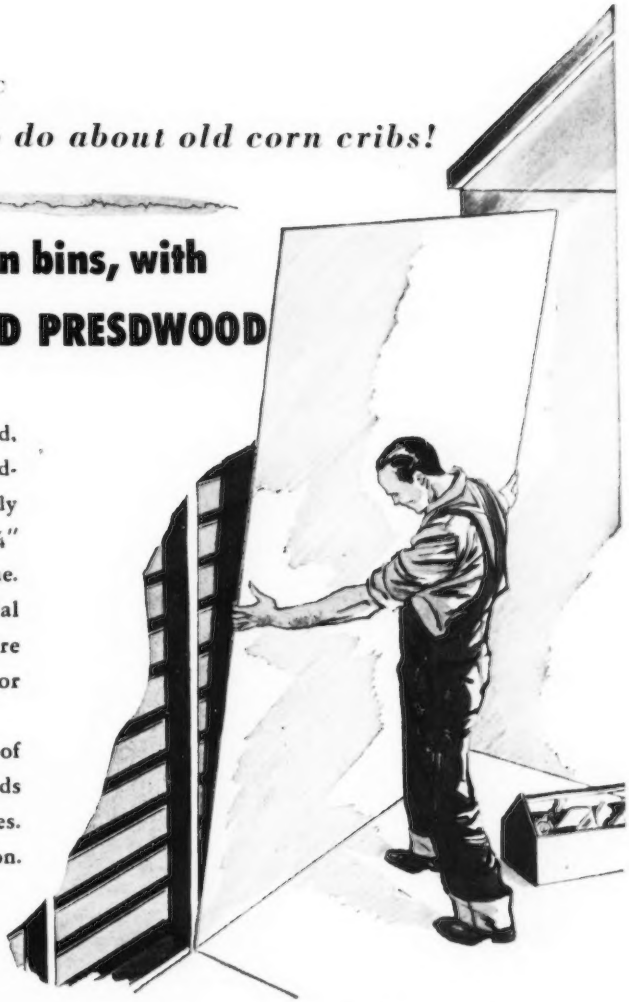

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TECHNICAL ABSTRACTS

(Continued from page 442)

Stress and Design at Junction Points, with special reference to structures subjected to torsional stresses (W. Bergmann). When twisting steel-framed structures of sectional steel, severe stresses are set up particularly at the junctions. These stresses are produced largely by impeding the cross sectional bulging under torsion. Over the free length of the bars the stresses remain, in general, moderate. Illustrations show stress areas occurring in structural members subjected to torsion and bending, which areas are visualized by applying the extension crack method. Finally, by reference to a series of examples, the article draws from the experimental data certain conclusions concerning design.

The Use of Models to Assist the Redesigning of Agricultural Machines (W. G. Brenner). The article distinguishes between models as used for demonstrating the styling, operation, design, and strength. By studying these scale miniatures the time required for developmental purposes can be considerably reduced, and the manufacture of the fire prototype of natural size can commence at a higher level of development. Perspective drawings and paper models from sheet metal patterns render valuable aid as intermediaries between the drawing board and the workshop. Strength problems can be cleared up better and quicker in basing on models than on laborious calculations which, in most cases, can only be solved if simplified by making certain assumptions.

The Laws of Static Similarity in Models (W. Bergmann). When the results of strength or stiffness tests on models are applied to the prototype, it is necessary to consider the laws of static similarity. Between the relationship of the external forces and the relationship of the lengths of prototype and model there exists a simple square law which, as is shown, applies equally to all stress conditions. The model law is illustrated by several examples.

The Mechanical Behavior of Soil Under Rolling Loads Imposed by Wheels, and Under Cultivation (W. Sohne). The design of agricultural machines depends more or less on the characteristics and properties of the soil. It is therefore the task of soil mechanics, as concerned with agricultural machinery, to investigate the laws governing the interaction of machine and soil. The subjects discussed include certain laws relating to the deformation of the soil under the influence of external compressive forces, crushing stresses in the soil resulting from external compressive forces, horizontal forces and shearing stresses, wheel slip, and processes connected with soil cultivation.

Designing Agricultural Conveyor Fans (G. Segler). The article gives the basic calculations for designing agricultural conveyor fans. By applying them the designer is able, for example, to relate the pipe width and the fan capacity to each other in such a manner that the fan supplies the desired volume of air at the required pressure with maximum efficiency. Although the types of fan used with the various agricultural commodities differ widely, the processes occurring in the air generator, the air lock and the pipeline, seen from the flow theory aspect, still obey the same laws. The article gives empirical values, based on practical experiment, for the design of fans.

Grading Seed Grain by a Horizontal Blast of Extreme Constancy (H. Blenk). A general insight into the principles of air dressing, at least for bodies of uniform average shape, can be gained from the well-known laws relating to air resistance. Consideration of the advantages and disadvantages of horizontal and vertical blast revealed the necessity of conducting experiments in a good horizontal wind tunnel. The initial results of these experiments show what can be achieved in practice. Multiple subdivision of the grading box facilities quantitative evaluation of the experiments, a factor which is also of importance to that side of the problem which is concerned with cultivation.

Germinating and Growth Capacity of Seed Grain Dressed by a Uniform Horizontal Blast (M. Thielebein). The physical composition and biological properties of beet and corn seed were determined after grading in a horizontal wind tunnel. The clarification of these factors is of the utmost importance to research on seed grain.

Grading Fruit Seeds by Horizontal Blast (H. Schander). The horizontal dressing machine described in the previous article has proved of particular value for grading apple cores. The cores associated with the various air gradings exhibit distinct biological differences. Time and labor are saved by using the horizontal dressing machine.

Disk Plows (W. Sohne). Disk plows have so far only been able to establish themselves to a slight extent in German agriculture. However, it can be assumed that applications for the disk plow will eventually be found in Germany too. The article reports on investigations, due to the author and American sources, into the special characteristics of disk plows and the forces associated with such plows. The construction used for connecting the tractor to the disk plow in the case of trailed, direct-coupled or mounted disk plows are discussed, and certain design details are explained by reference to American examples of disk plow. In conclusion the article deals with the advantages and disadvantages of using disk plows.

(Continued on page 450)

New "Monarch"

BY MILSCO *America's Leading Seat Specialists*

FOR MANUFACTURERS OF MOBILE EQUIPMENT

No. 344 *With Or Without Fore And Aft Attachment*

★4 Point Body Comfort

The new Milsco "Monarch" features deep cushion comfort with full 4-point body support. Ruggedly built; attractively styled. Designed for stepped-up work efficiency on many types of mobile equipment. (Sold to equipment manufacturers only.) Write for catalog on your company letterhead.

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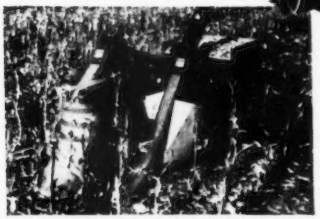
The Oliver Model 33 Self-Propelled Combine with 12' or 14' header ... Fafnir equipped

Fafnir Wide Inner Ring Ball Bearing Self-Locking Collar easiest of all to install.



The Oliver No. 5 Single Row Corn Picker-Husker

The Oliver No. 4 Tractor Mounted Corn-Picker-Husker.

In building farm machinery, The Oliver Corporation uses Fafnir Ball Bearings at many important turning points, not only to bring out the full advantages of design features but to assure "on Schedule" performance.

The Model 33 self-propelled combine is equipped with eight Fafnir Wide Inner Ring Ball Bearings with Self-Locking Collars plus nine Radial Ball Bearings. Those on the fan shaft, rear beater shaft, cylinder shaft and idler pulley straw elevator drive, have Fafnir Mechani-Seals that positively keep lubricant in — contaminants out. Models 4 and 5 corn pickers feature the famous Fafnir Flangettes.

More and more farm machinery is being equipped with Fafnir Ball Bearings because of their wide selection of types and sizes, uniformly high quality, easy installation, plus ... the Fafnir "attitude and aptitude", a way of looking at bearing problems from the designer's viewpoint — an aptitude for supplying the right bearing to fit the need, gained from over 40 years of experience in the manufacture of ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.

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BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

Applicants for Membership

The persons listed below have applied for admission to membership or for transfer of membership grade, in the American Society of Agricultural Engineers. Members of the Society who wish to commend or object to any of these applicants, should write the Secretary of the Society at once.

ANG, IGNACIO R.—Soil technologist, Bureau of Soil Conservation, Department of Agriculture and Natural Resources, Manila, Philippines.

BEALE, JACK G.—Consulting engineer, 60 Hunter St., Sydney, N.S.W., Australia.

BOESCH, PETER W.—Farmer, Gray, Sask., Canada.

BONNER, WILLIAM C.—Student, New Mexico College of Agriculture, State College, N. M.

BROWN, JERRY E.—Student, New Mexico College of Agriculture, State College, N. M.

CATON, JOHN B.—Supervisor, farm products sales, Rilco Laminated Products, Inc., W-2501 First National Bank Bldg., St. Paul 1, Minn.

EWING, THOMAS C.—2nd Lt., U.S. Air Force, Scott, Miss.

GORDON, THERON C.—Parts dept., Willamette Tractor Co., Albany, Ore.

GREEN, ROBERT H.—Engineer trainee, field test dept., New Holland Machine Co., New Holland, Pa.

GUNTHER, GUSTAV A.—District mgr., Chicago office of Chain Belt Co., Milwaukee, Wis.

HAGER, WILLIAM C.—Agricultural engineer, Lawrenceburg Electric System, Lawrenceburg, Tenn.

HARRIS, DAVID M.—Sales dept., Armco Drainage & Metal Products, Inc., Middletown, O.

JOHNS, HOWARD W.—Trainee, Ralston Purina Co., St. Louis 2, Mo.

JONES, BILLY P.—Mechanical engineer, Redstone Arsenal, Huntsville, Ala.

JUDY, EDWIN S.—Education mgr., Ohio Tractor & Implement Co., Columbus, Ohio.

KEGG, VAUGH C.—Buyer, farm water handling equipment, United Cooperatives, Inc., Alliance, Ohio.

KIDSTON, GEORGE W.—Student, Oregon State College, Corvallis, Ore.

LINDBLAD, JOHN W.—Student, Univ. of California, Davis, Calif.

LITTERAS, JOHN J.—Student, Univ. of Nebraska, Lincoln, Nebr.

MACHMEIER, ROGER E.—Sales engineering, irrigation systems, The Hilton Co., 12300 W. Lisbon Ave., Milwaukee 16, Wis.

MITCHELL, WILLIAM G.—Agricultural engineer, Duke Power Co., Greensboro, N. C.

MITTENBERGS, ALEXANDER A.—Design engineer, New Holland Machine, Division of the Sperry Corp., New Holland, Pa.

MOORE, HARRY E.—Product education mgr., Bonnard Equipment, Ltd., 2387 Remembrance Rd., Lachine, Quebec, Canada.

NORTH, IRWIN G., JR.—Student, Univ. of California, Davis, Calif.

OKSANEN, ERKKI H.—Graduate student, agricultural engineering dept., Michigan State College, East Lansing, Mich.

PATTISON, ORVILLE H.—Farm mgr., O. E. Pattison, Star Route, Clovis, N. M.

PETRAN, DONALD W.—Farmer, Paul H. Petran Farms, Box 409, Albert Lea, Minn.

SHEPARD, FRANCIS D.—Farm service repr., Niagara-Mohawk Power Corp., Avon, N. Y.

SPENCER, JOHN N.—Regional supervisor of operations and maintenance, Bureau of Reclamation, USDI, Region 7, Bldg. 46, Denver Federal Center, Denver, Colo.

SPRICK, WILLIAM L.—Trainee, Caterpillar Tractor Co., Peoria, Ill.

THOMAS, ROBERT E.—Trainee, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

TWEEDY, ROBERT H.—Product specialist, E. I. du Pont de Nemours & Co., Wilmington, Delaware.

TYSON, SAMUEL D.—Trainee, Minneapolis-Moline Co., Minneapolis, Minn.

VON BARGEN, KENNETH L.—Student, Univ. of Nebraska, Lincoln, Nebr.

WALLS, THOMAS E., JR.—Student, Univ. of California, Davis, Calif.

WEAVER, WALLACE C.—Junior rural service engineer, Alabama Power Co., Birmingham, Ala.

WHISENANT, W. C.—Electrical development repr., Tennessee Valley Authority, Chattanooga, Tenn.

WINTON, JOSEPH—Farm sales engineer, Libbey-Owens-Ford Glass Co., Toledo, Ohio.

TRANSFER OF MEMBERSHIP GRADE

JONES, JOSEPH K.—Sales mgr., Farm Machinery, Inc., Greenville, Miss. (Associate Member to Member)

MUIRHEID, BENJAMIN F.—Extension specialist in agricultural engineering, University of Illinois, Urbana, Ill. (Associate Member to Member)

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Violent Vibration

CAN'T REDUCE THE ACCURACY OF

RUGGED Rochester GAUGES

Specially designed for heavy-duty service, Rochester Tractor Gauges are built with vibration and pulsation dampeners.

There's no danger of accuracy loss through rough riding. Even high overloads can't damage their sensitive movements, or cause their pointers to flutter. They *keep on* delivering accurate readings, too, year after year, because of their unusually rugged construction.

And for *extra* protection, Rochester gauges are *permanently* sealed behind heavy glass crystals. Dirt and water just can't get in. This outstanding dependability has made Rochester Gauges the choice of all leading tractor manufacturers for more than 35 years.

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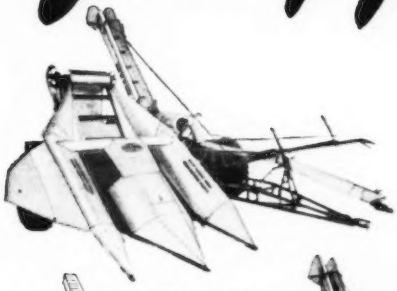
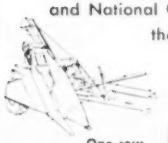
ROCHESTER GAUGES

DIAL THERMOMETERS GAUGES AMMETERS

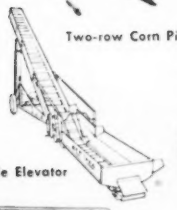
Flowing Gold from field to crib via NEW IDEAS



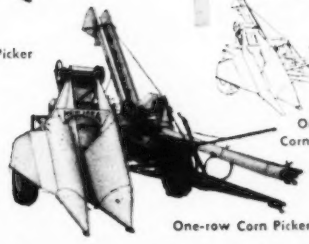
Two-row Corn Picker



One-row Corn Snapper



Portable Elevator



One-row Corn Picker

NEW IDEA one and two row pickers, wagons, wagon boxes, elevators do a complete corn harvesting job. They make the farmer independent of most weather and labor conditions, enabling him to get his corn in when it's ready, including down stalks and nubbins. NEW IDEA pickers are tops—in 1951 the NEW IDEA one row picker won first place in all accredited State and National Corn Picking Contests. Complete information on these tools is available without obligation. Write us.

NEW IDEA
FARM EQUIPMENT COMPANY
SUBSIDIARY AVCO MANUFACTURING CORPORATION
COLDWATER, OHIO

NEWS FROM ADVERTISERS

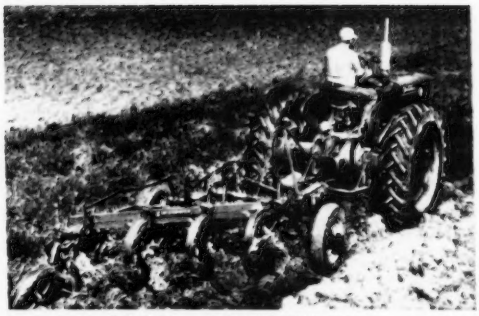
New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

Four New Tractor Models

The International Harvester Co., Chicago, Ill., has just announced four new tractor models in the three to four-plow power class, to replace the Farmall M and MD and the McCormick W-6 and WD-6 standard tractors. These four new tractors have greater power, faster field speeds, and many new design features which will increase their work capacity and ease of handling.

All-purpose gasoline, distillate, or LP gas-powered models will be known as the Farmall Super M. The diesel-equipped model will be known as the Farmall Super MD. The two new wheel tractors will be known as the McCormick Super W-6 and the diesel-powered McCormick Super WD-6.

The Farmall Super M has 21 per cent more power than the former Farmall M. It develops 47½ hp at the belt and 42 dbp, by manufacturer's rating. New field speeds include 2⅝, 3⅞, 5 and 6⅞ mph on 12 x 38 tires. The combination of greater power and field speeds give the new tractors an unusually large capacity for work. Farmers can haul bigger implements or pull their present implements in a higher gear, to do more work per day.



One of the new Farmall Super M tractors

Field tests indicate that the Super M will pull a regular 4-bottom moldboard plow in practically all soil conditions, turning up to 20 acres a day. The tractor will cover up to 50 acres a day with a 10-foot tandem disk harrow, and have power to pull a pegtooth harrow or ground roller at the same time. It will drill small grain at the rate of 65 acres a day and cultivate up to 60 acres or more with 4-row equipment.

The full line of McCormick equipment — 48 basic units in all — that fit the Farmall M will fit the new Farmall Super M tractor. Hydraulic control for mounted implements is regular equipment and hydraulic Farmall remote-control for trailing equipment is available.

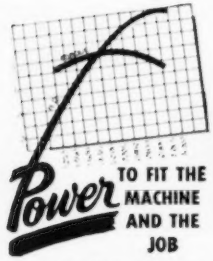
The new Super tractors have been built heavier throughout to handle the increased power and speed. The increasingly popular self-energizing, double-disk brakes have been added to make the big tractor easier to handle, and a comfortable hydraulic seat is now regular equipment. A big steering wheel and controls which respond to light pressure also contribute to easy handling.

New Manure Spreader

A new manure spreader recently added to the line of Dearborn Motors Corporation, Birmingham, Mich., is designed for the dairy man or stock feeder who must move manure quickly and economically. The all-steel box has a 50-bu capacity. This size is growing in popularity, particularly in those states having "daily clean-out" laws for dairy operation. The spreading mechanism consists of a 6-bar lower cylinder and a 3-bar upper cylinder used in conjunction with a hammermill-type wide-spread to cover a 6-ft strip of land with an even coating of finely shredded manure. The

(Continued on page 450)

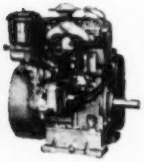
The new Dearborn manure spreader



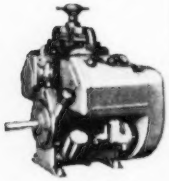
WISCONSIN-Powered

Wiebe Green-Crop Loader

Single-cylinder 3 to 9 hp. models.



2-cylinder 7 to 13 hp. models.



V-type 4-cylinder 15 to 30 hp. models.

Crops like peas and green beans require harvesting at *peak of flavor* in the *shortest time*. That's why the majority of firms who pack frozen foods throughout the West rely on Wiebe Green-Crop Loaders, built by Wiebe Manufacturing Co., Hollister, Calif. . . . powered by Wisconsin Heavy-Duty Air-Cooled Engines.

Wherever *your recommendations* call for 3 to 30 hp. power, you can confidently endorse Wisconsin Engines . . . the power dominating the farm field in its horsepower range. Such features as tapered roller bearings at both ends of the crankshaft, minimizing bearing failure through absorption of all thrusts, along with cooling by *AIR alone* are *two* good reasons for their popularity. Positive lubrication, reducing engine wear to a minimum, *plus* an easily-serviced OUTSIDE magneto with impulse coupling for faster starts, winter and summer, are others.

Write today for important specifications covering all 4-cycle single-cylinder, 2-cylinder and V-type 4-cylinder models, 3 to 30 hp.

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World's Largest Builders of Heavy-Duty Air-Cooled Engines

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A New Way.. TO SOLVE AN OLD, OLD PROBLEM

Dearborn Rear Mounted Loader loading manure into Dearborn Manure Spreader.

After only a few months on the market, this new Dearborn Rear Mounted Loader is winning recognition as the answer to an old, old problem.

It's the problem of finding relief for sore muscles and strained backs caused by lack of a simply designed, sturdily built loader that's also really low in price! A loader that, after original installation, can be attached to or removed from the Ford Tractor in less than 5 minutes! A loader that enables a farmer to load manure or other materials during his busy season without *tying up his tractor!*

This Dearborn Loader has a breakaway lift of 1100 pounds and will raise a 460 pound load as high as six feet. (To do this you merely move the Ford Tractor's hydraulic lever). Since all this weight is on the tractor's rear wheels excellent traction is assured, even in slippery conditions.

Close coupling and low mounting permit a farmer to use this outfit *inside* barns and sheds—even those with a low ceiling. Hand forks get rusty and muscles take a rest!

Here is just one more example of how Ford Farming is helping to make farm work easier and farm life better. For more information on this fascinating story, see your nearby Ford Tractor dealer or write to us direct.

DEARBORN MOTORS CORPORATION • Birmingham, Michigan

National Marketing Organization for the Ford Tractor and Dearborn Farm Equipment

Ford TRACTOR

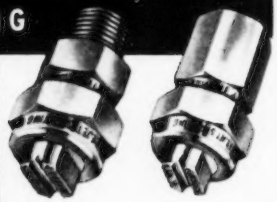
Ford Farming

MEANS BETTER WORK
. . . MORE PRODUCTION

SPRAY NOZZLES FOR BETTER, FASTER FARM SPRAYING

TEEJET performance features

- Super precision orifice tips . . DRILLED and MILLED for uniform spray and exact volume control.
- Interchangeable orifice tips . . . in every type and capacity from one gallon per hour and up.
- Eleven different spray angles from 0° (solid stream) to 150°.
- Unconditionally guaranteed for performance as specified.
- Factory inspection and test of all nozzles and tips before shipment.



The investment a farmer makes in chemicals, equipment and time will dependably produce a profit when TeeJet Spray Nozzles are installed on the spray boom. TeeJet nozzles are precision made to provide the best in performance from both equipment and chemicals. Proved by test in every type of farm spraying. For complete information, write for Bulletin 58 . . . the comprehensive reference manual for farm spray nozzles, strainers and fittings.

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DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

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NEWS FROM ADVERTISERS

(Continued from page 448)

eight cleaver-shaped blades on the widespread are designed to eliminate vibration. Rates of spreading can be varied from 4 to 40 loads per acre at five different speeds. Construction features include a welded box made of specially treated steel, bracing at points of stress, and heavy main tongue members extending to the axle, minimizing wear and tear on the body. The spreader can be attached or detached easily from the Ford tractor, even with the Dearborn rear-mounted loader attached. An adjustable stand for the tongue is furnished as standard equipment. The box is 8 ft long and 3 ft wide. Over-all weight of the spreader, with tires, is 840 lb.

Dearborn Lime and Fertilizer Spreader

Dearborn Motor Corp., Birmingham, Mich., has added a 10-ft spreader to the Dearborn line of farm equipment. The 10-ft hopper body has a depth of 18 in. and a capacity of from 950 to 1,100 lb, depending on the type of fertilizer. The bottom, form-fitted to the agitator for uniform, clog-free flow of fertilizer, is perforated by 20 square dispersal holes. A split, disk-type agitator pulverizes the fertilizer and

Dearborn 10-ft lime and fertilizer spreader

forces the mixture through the dispersal holes. The flow selector lever, accessible to the operator from the tractor seat, regulates flow from 150 up to 5,000 lb per acre. Spreader can be quickly attached to the drawbar of any tractor. A tow plate of reinforced steel is located at the rear of the hopper for pulling harrows or other equipment.

Technical Abstracts

(Continued from page 444)

Further Investigations into the Dressing of Seed Grain by Horizontal and Vertical Blast (H. Blenk and H. Trienes). By means of a specially constructed horizontal dressing machine further experiments on seed grading were conducted with the object of improving the process. Comparisons between the new machine and two seed-dressing machines with vertical blast revealed differences in favor of the horizontal machine when comparing air dressing only, but gave a slight advantage to the seed-dressing machines with vertical blast when the latter were used (as is normally the case) with sieves and indented cylinders.

Air Flow in Agricultural Engineering (H. Blenk). Part I presents well-known facts from the general theory of fluid flow which are of particular importance to the designer of agricultural machines. Part II presents details of flow measurements conducted on certain types of agricultural machine, and explains how improved flow was sought by changed design, and was confirmed by a repetition of the measurements. Part III gives an extract from the investigations into the shifting of seed by a horizontal blast; this subject is dealt with in detail in volume 2 of the present series.

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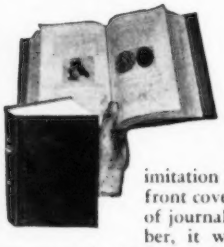

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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail, for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—JANUARY—O-484-553. FEBRUARY—O-503-556, 502-557. MARCH—O-537-558, 552-560, 559-561, 576-562. APRIL—O-592-564, 596-565, 584-566, 602-567, 603-568. MAY—O-619-570, 630-572. JUNE—O-657-573, 672-574.

POSITIONS WANTED—FEBRUARY—W-504-92, 528-95. MARCH—W-514-97, 538-100, 542-102, 560-103, 573-105, 564-106. APRIL—W-588-107, 590-108, 592-109, 612-111. MAY—W-608-112, 604-113, 626-114, 629-115, 601-116. JUNE—W-640-117, 633-118, 636-119, 674-120, 678-121, 661-122.

NEW POSITIONS OPEN

DESIGN ENGINEER for development work on tillage, planting, and cultivating implements with a major manufacturer. Midwest. BS deg in agricultural engineering. Implement design or equivalent experience 2 yr or more. Usual personal qualifications for commercial design. Farm background preferred. Salary open. O-712-575

CHIEF ENGINEER to direct and supervise engineering, research, development, quality control and inspection for western manufacturer of tractors and harvesters, with engineering department of 10 to 15 engineers and assistants. Engineering degree and minimum of 10 yr experience in harvester and tractor engineering and manufacture. Executive and administrative ability, good personality and ability to work with others. Prefer married man with family. Established company with $3,000,000 current annual volume, increasing markets, and two new product developments. Desirable location in California. Age 35-50. Salary $8000-10000. O-622-576

NEW POSITIONS WANTED

DESIGN or development in power and machinery field, especially on mounted implements and trailed plows, with manufacturer, anywhere in U.S.A. Special training in general machine design, Higher State College, Bremen. Farm machine design experience 1926-35 and 1950 — present, in Germany. Other design and related work, 16 yr. Married. Age 48. No disability. Available on reasonable notice. Salary open. W-694-123

DEVELOPMENT, research, or extension in power and machinery, soil and water or product processing field, with industry or public service. Pacific Coast or other mild climate location. BS deg, 1950, University of California. MS deg, 1952, Oregon State College. Graduate research assistant, 2 yr. Teaching course in agricultural engineering, 2 quarters. Summer and part-time experience as farm worker, carpenter and assistant to mathematics professor. Single. Age 24. No disability. Available July 15. Salary open. W-691-124

RESEARCH in soil and water field with industry or public service, in Southeast. BS and MS deg in agricultural engineering, 1949 and '50, Virginia Polytechnic Institute. Farm background. Vocational agriculture instructor 2 yr. War service in Marines, 2½ yr. Married. Age 28. No disability. Available August 1. Salary open. W-682-125

DEVELOPMENT, research, or teaching in power and machinery or farm structures field with college or industry. Any location. BS deg in agricultural engineering, 1951, University of Georgia. Farm background. Student research assistant one year while in school. Additional training and experience in drafting, farm equipment sales, and inspection and testing of instruments. War enlisted service in Navy. Single. Age 27. No disability. Available on reasonable notice. Salary open. W-700-126

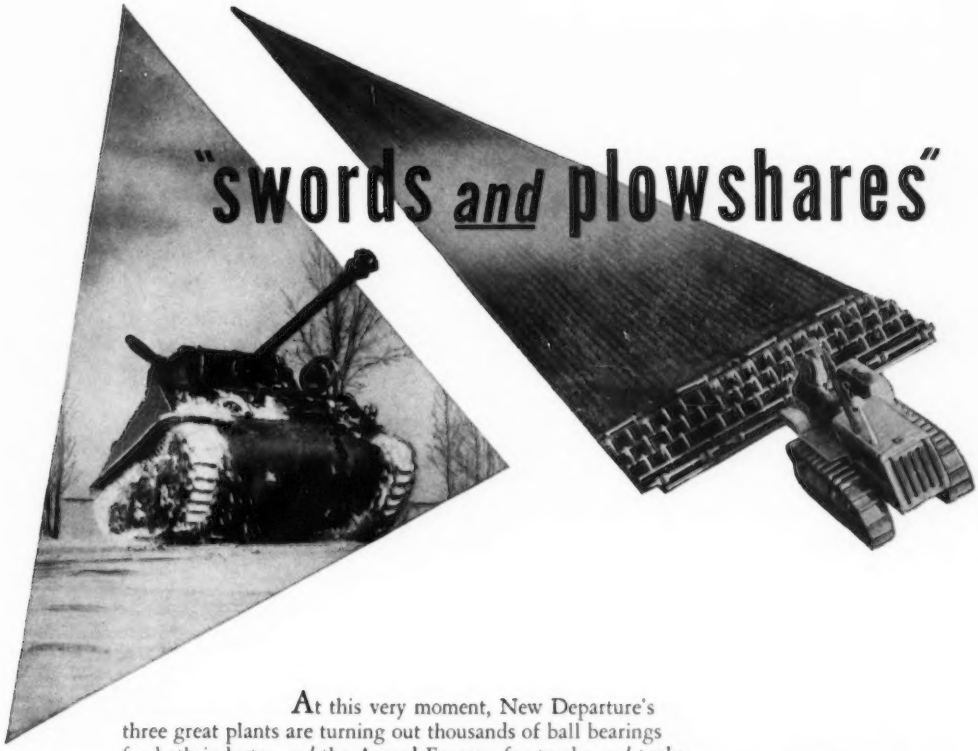
TEACHING in farm structures field in college agricultural engineering department, anywhere in U.S.A. BS deg in agriculture 1946, agricultural engineering 1947, Ohio State University. MS deg in agricultural engineering expected August, 1952, University of Missouri. Farm background. With consulting engineer 1 yr, S.C.S. 6 mo., state highway department 2½ yr, 4-H Club advisor 2 yr. Assistant instructor half-time while working on MS deg. Registered Professional Engineer (Ohio). War noncommissioned service in Air Corps 28 mo. Married. Age 31. No disability. Salary $6000. W-704-127

NEW BULLETINS

Agricultural Hydrology as Evaluated by Monolith Lysimeters, by L. I. Harrold and F. R. Dreibelbis, Technical Bulletin No. 1050 (December, 1951) Soil Conservation Service, USDA (Washington, D. C.). A 149-page summary on methods, installations, and results.

Comparative Tillage Tests at East Lansing, Michigan, by James Tyson and George A. Crabb, Jr. Article 34-50 (May, 1952) reprinted from the Quarterly Bulletin of the Michigan Agricultural Experiment Station (East Lansing). Progress report on comparison tests of conventional plowing and three variations of mulch tillage, for 6 yr, with results generally favorable to conventional plowing but indicating possibilities with mulch tillage when related weed control and fertilization problems are solved.

"swords *and* plowshares"



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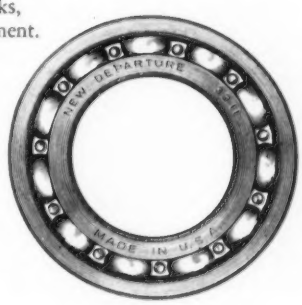

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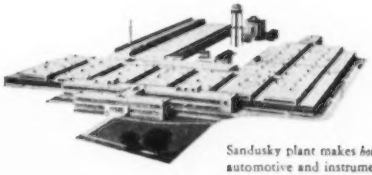

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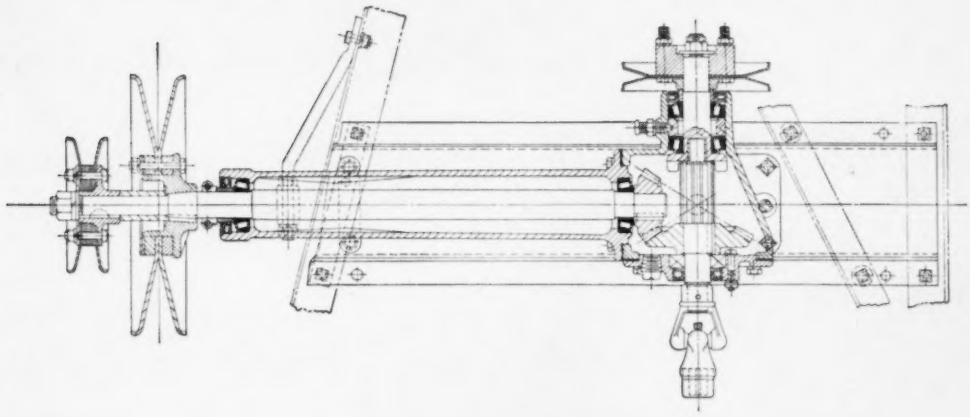

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